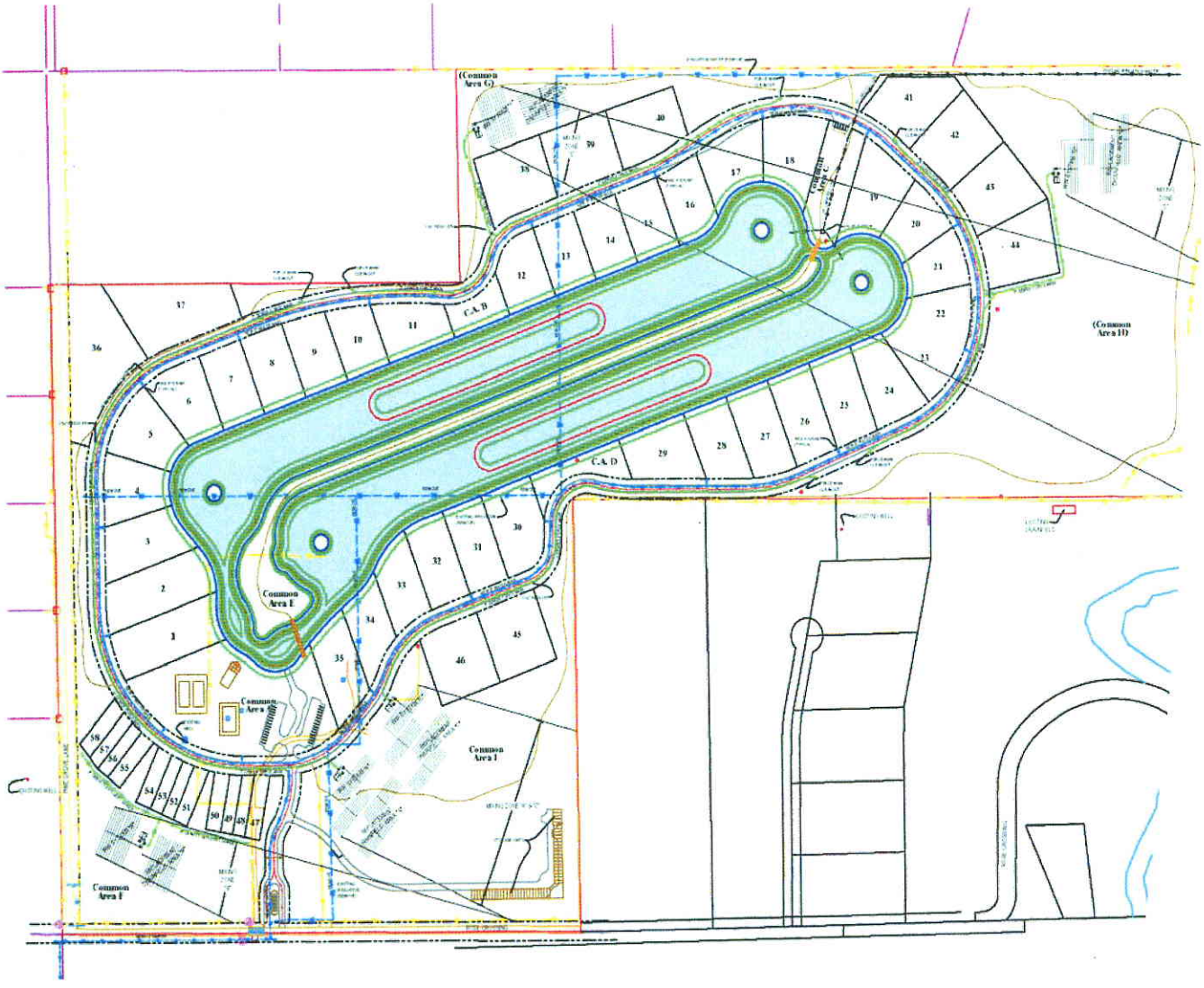
Rosewater

Montana's Premier Water Ski Community



Operation & Maintenance Manual

ROSEWATER OPERATION & MAINTENANCE MANUAL

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ROSEWATER
MONTANA'S PREMIER WATER SKI COMMUNITY
OPERATION & MAINTENANCE MANUAL

1.0 GENERAL INFORMATION

Rosewater is Montana's premier water ski community situated just north of Kalispell, MT with unobstructed views of the Whitefish Mountain Resort, Glacier Park and the Swan Range. The center-piece of Rosewater is a water ski lake constructed solely for the use of Rosewater residents and their guests. The lakes offer residents the unequalled opportunity to ski, wake board, tube, barefoot and trick ski on their own private water-use facility.

To keep Rosewater a premier water ski community, it will be imperative the lakes, and all related appurtenances, be properly operated and maintained. The developers have expended considerable effort and resources in making the lakes a showpiece amenity and considerable effort and resources will also be necessary to keep it that way. This Operation and Maintenance (O&M) Manual is intended to provide the homeowners and operating and maintenance personnel with specific information on lake construction, watercraft requirements, maintaining water levels, monitoring wells, leak detection and vegetation control necessary to enhance and maintain water quality.

The Rosewater Homeowner's Association will be responsible for operation and maintenance of the water ski lakes, and all other Rosewater amenities, and all homeowners (lot owners) in Rosewater will be members of that association.

1.1 Lake Description & Details

The lakes were designed to meet or exceed all requirements for length, width, depth and lake bottom grading. Figure 1 shows a plan view of the Rosewater community and centerpiece lakes and Figure 2 shows elevation section views of the lakes and a typical lot. The lake is actually two lakes in one, joined only at the west end, providing two separate water ski courses. Although essentially just one lake with two separate water ski courses, for descriptive purposes, they will be referred to collectively as the "lakes" or individually as the North and South Lakes throughout this O&M Manual.

There is a 20-ft. easement area surrounding the lakes for the purpose of providing access for maintenance, and homeowners shall be aware that this easement area cannot be obstructed by any buildings, fences or landscaping, other than lawns.

Each lake is 2,300 ft. in length and 220 ft. wide with slightly widened bulb-like ends to facilitate turn islands. The lakes are basically mirror images of one another. As shown in Figure 2, the lake depths are generally 5 to 8 ft. with the deeper 8 ft. sections along the centers of each lake. To mitigate wave action and wave return, the lakes are graded at a 12 ft. horizontal to 1 ft. vertical slope (12H:1V) for a distance of 12 ft. – 2 ft. above the water's edge and 10 ft. below or into the lakes. The lakes are then graded at a 6H:1V slope for 6 ft. and then at

3H:1V for 9 ft. At this point, 27 ft. from the water's edge, the water depth is 5 ft. The lake bottom then slopes at a gentle grade of about 6% to a depth of 8 ft. at the center. The total water volume in the lake(s) is approximately 50 million gallons or 153 acre-ft. The total water surface area is about 27 acres.

Construction of the lakes consisted of stripping approximately 15 inches of topsoil from the entire lake area and the surrounding residential lots and common areas. This topsoil was stockpiled and later used as cover material throughout the Rosewater property. The lake area was then excavated to establish the design grades and elevations as mentioned above. This excavated material was spread out, graded and compacted over the surrounding residential lots and commons areas to create building sites a minimum of 4 ft. higher than the high water elevation of the lakes (See Figure 2). The center strip that separates the North and South Lakes is 50 ft. in width and is constructed 2 ft. higher than the high water level of the lakes.

A 30 mil PVC liner was installed over the smooth and uniformly graded and compacted surface, and the liner was then covered with 18" of excavated sandy silt to silty sand native material. It should be noted that native soils throughout the Rosewater property are ideal for installation of the PVC liner, both for the prepared surface on which the liner is installed and for the material used to cover the liner. The native soils consist of a sandy silt or silty sand with no, even small gravel-sized, coarse fragments. A synthetic geotextile fabric is sometimes used beneath and/or above PVC liners to protect the liners from tears or punctures in installations with rocky soil characteristics; however, because of the fine grained rock-free soil throughout Rosewater, a synthetic geotextile fabric was not required or recommended for the PVC liner installation at Rosewater.

1.2 PVC Liner Details

As shown in Figure 2, and as described above, the lakes will be lined with a 30 mil PVC liner. Specifications that govern the material, testing and installation requirements (Specification Section 02770) for the PVC liner at Rosewater are included in Appendix A at the end of this Manual. This same type of liner material is used in solid waste landfills, toxic waste sites and sewage lagoons to contain contaminated water and to protect groundwater, and this same type of liner is also used in hundreds of thousands of man-made ponds and lakes around the world. The Rosewater Lakes will contain Whitefish River water and not contaminated water.

The liner material will be manufactured, supplied and installed by either Colorado Lining International; Northwest Lining; or another reputable geomembrane liner manufacturer. The 30 mil PVC liner will be manufactured and fabricated in accordance with the PVC Geomembrane Institute (PGI) Quality Control Document and the National Science Foundation (NSF) Standard 54 – Flexible Membrane Liners.

The company that will supply and install the liner at Rosewater, will fabricate large 20,000 (+) sq. ft. sections of liner material at the factory and then ship the large sections to Rosewater for installation. All "factory" seams will be thermal welded and air tested at the factory. All "field" seams will also be thermal welded and

tested in accordance with ASTM D7177 – air channel test for PVC geomembrane field seams - prior to covering. The in-place liner will provide a long-term impermeable containment system.

Virtually all PVC liner manufacturers warrant their liner material(s) for 20 years but the expected life of the liner is significantly greater than that. The long warranty period is testimony that the material is expected to maintain its strength and integrity for a considerable period of time, well beyond the established warranty period.

1.2.1 Longevity of PVC Liners

Several studies have been included in Appendix B of this Manual documenting the longevity or long-term durability of PVC liners. In one study titled, *"10 Mil PVC Performs After 25 Years on the Job"*, a 10 mil liner installed in 1968 at a golf course irrigation pond in Northern Michigan was excavated as part of a pond enlargement project. The liner had been covered with 12" of sand and about 6 to 8" of accumulated silt. Tests on the 10 mil liner resulted in an elongation at break of 267% which exceeded the original specification of 250%. Peel tests of both factory and field seams were above the minimum requirements, as were tests for shear and modulus. This liner was reported to have provided 25 years of leak free, trouble free and maintenance free service.

In another study titled, *"Thirty-Year Durability of a 20-Mil PVC Geomembrane"*, twenty circular agricultural ponds, constructed in 1971 at the W.K. Kellogg Biological Research Station in Hickory Corners, Michigan, were removed as the ponds had become congested with dense stands of cattails, trees and other vegetation and the ponds needed to be cleared and relined for new experiments. Each of the existing ponds had been lined with a 20 mil fish-grade PVC liner and none were reported to be leaking. Observations of the liners showed an absence of root penetration through the liner. All of the tree and cattail roots grew down to the PVC liner and then grew horizontally along the top of the liner. A lack of holes indicated the liners resisted biological attack from microorganisms. Tests indicated that the tensile behavior was well within current specifications for new 20 mil PVC liners. Results showed that the material properties of the 30-year old PVC liner exceeded NSF Standard 54 required valves and the more restrictive PGI values.

From published research on PVC liners, it can be safely concluded that a properly fabricated, seamed and installed PVC geomembrane liner, bedded on and covered with fine grained rock-free soils, can provide leak-free, trouble-free and maintenance-free service for an indefinite period of time.

1.2.2 Protection of Liner

As mentioned above, the PVC liner is protected from damage by 18 inches of fine-grained, gravel-free cover material. Twelve inches of cover is recommended by virtually all liner suppliers, including Colorado Lining; however, 18 inches of cover material was used for the Rosewater lakes to provide additional protection.

Although the cover material provides adequate protection from the proposed water use activities at Rosewater, Homeowners and lake users shall be aware that the liner can be punctured if the cover material is penetrated by stakes, posts or piles. The following rules shall apply:

- No buildings, structures or fences, of any type or design, are allowed within 20 ft. of the high water mark.
- No landscaping, other than lawns, will be allowed within 20 ft. of the high water mark
- Plans for **ALL DOCKS** shall be reviewed and approved by the Architectural Review Committee **PRIOR TO** construction.
- No dock will be allowed if driven piles are proposed for support or anchorage.
- Anchorage for floating docks shall be located no closer than 20 ft. from the high water mark.

1.3 Maintaining Water Level

Water to fill and maintain water level in the lakes is pumped from the Whitefish River by a pump system located adjacent to the river. Water is pumped through a 10" PVC water line from the river to the lakes. The 10" water line, from the northeast corner of Rosewater property down to the pump system, crosses private property and there is an existing 10-ft. easement is along this section of water line. Access for maintenance and repair of the water line, pump system or river intake shall be confined to this 10-ft. easement.

The lake water level is controlled by a pressure transducer, programmable controller and radio telemetry system. When the water falls to a preset level (e.g. 3" below the high water level) the transducer sends a 4 – 20 mA signal, proportional to the water level, to a programmable controller and a signal is then sent via a radio telemetry system to the pump at the river. The pump starts and feeds water to the lakes. When the water level rises to the preset high water level, a signal is sent to the pump to shut down. High level and low level alarms are provided and a telephone dialer will alert maintenance personnel to any alarm condition.

Operating and maintenance personnel will shutdown and winterize the Whitefish River pump system at end of September each year and will restart the system on or about April 1 of each year. Water level in the lakes will be lowered to at least 9" below the normal high water level by the first of November each year to provide storage for winter and early spring precipitation.

1.3.1 Evaporation

A drop in the water level can result from evaporation and/or irrigation. Evaporation rates are obviously dependent on several variables, ambient air temperature being only one. Other factors include water temperature, humidity, precipitation and air movement or wind. Because of that, evaporation rates vary significantly throughout the year and from year to year. Based on studies at Hungry Horse Reservoir, on average, the only months of the year where there is a net loss of water - evaporation losses are greater than gains from precipitation - are July, August and September. In those months, net evaporation losses are 3.4", 3.9" and 2.4" respectively. With a water surface area of 27 acres, water loss during those months would be 2.49 million gallons (mg), 2.86 mg and 1.76 mg respectively. The combined loss of water during July, August and September equates to almost 15% of the total water volume of the lakes.

1.3.2 Irrigation

Water to irrigate Common Areas A, C, E and portions of Common Areas F and I, will come from the lakes. Common Areas B & D will be irrigated from the Evergreen Water & Sewer District's domestic water supply system and Common Areas G, H and most of Common Areas F and I will not be irrigated. All residential lots will be irrigated from the domestic water supply system.

The total acreage to be irrigated with water from the lakes is approximately 13.5 acres. If water is applied at 1.0 inch per week, the total water used for irrigation purposes will be about 366,590 gallons per week or 52,370 gallons per day.

1.4 Types of Boats Allowed

The American Water Ski Association (AWSA) governs the types of towboats used in water ski competitions throughout the United States, and the AWSA's National AWSA Towboat Committee is charged with qualifying boats for use in water ski competitions. Boats to be used in competition must meet certain performance standards, including but not limited to power and acceleration, handling and maneuverability and sound levels. ***All boats used at Rosewater must be certified as meeting AWSA standards. Jet skis will not be allowed at Rosewater.***

All towboats shall be registered with the Rosewater HOA prior to initial use at Rosewater, and the HOA may require safety or other inspections from time to time as the HOA deems necessary. The owners of all towboats using the water ski lakes at Rosewater, whether resident or visiting, shall have liability insurance in the amount established by the Rosewater HOA. The Rosewater HOA shall be named on insurance certificates as an Additional Insured. Written verification of said insurance shall be submitted to the HOA prior to use of a towboat on the Rosewater water ski lakes.

1.4.1 Sound Levels

AWSA standards for sound levels are as follows:

Neither the average sound level for 36 mph passes nor the average sound level for 34.2 mph passes shall exceed 75 decibels (dB) at 125 ft. Any boat that fails to meet this standard will not be allowed to operate at Rosewater. Testing shall be conducted from shore as follows:

a. Place dB meter at a point 125 ft. from the centerline of the slalom course.

b. Align dB meter with Buoy #2 or #3 on the opposite side of the course from the buoy. That way the skier is farthest from the sound meter in order to minimize noise from the ski and skier.

A copy of the AWSA/USA Water Ski Towboat Policy Manual is included in Appendix C of this Manual.

1.5 Invasive Species Inspection Requirement

Every boat entering Rosewater property must have a seal or some type of verification from the Montana FWP, or a FWP Inspection Station, indicating that the boat and trailer have successfully passed an inspection for invasive species.

2.0 MONITORING WELLS

A series of six monitoring wells have been provided around and nearby the Rosewater water ski lakes. These monitoring wells are provided to monitor groundwater levels, to facilitate periodic sampling of groundwater and, in the unlikely event of a leak, to aid in determining whether or not leakage may be occurring from the lakes.

There is a perched aquifer beneath the Rosewater property that generally varies in depth from 30 to 40 ft. below the ground surface, and generally flows in a northwest to southeast direction – more specifically South 20° East. The perched aquifer discharges at lower portions along the river bank just east of Rosewater property and several seeps have been reported in this area. The discharge is to the Whitefish River and/or to wetland areas along the river. The monitoring wells in Rosewater will be drilled into this perched aquifer.

2.1 Description & Location

Figure 1 shows the locations of the six monitoring wells. Each monitoring well will be drilled through, and about 5 ft. beyond, the perched water table and a 2" PVC pipe will be installed to facilitate water level monitoring and sampling. The 2" PVC pipe will be screened at the water bearing formation and the upper end of each well will terminate inside a 6" steel casing with a lockable cover.

Two monitoring wells, MW #1 and MW #6, will have data-loggers that continuously monitor the respective water levels in each well. The data will be downloaded monthly from April through September and every two months from October through March. The data will be graphed so groundwater level trends can be

determined. In the remaining four monitoring wells, water levels will be measured once each month from April through September.

Water from each of the six monitoring wells will be sampled once each month from April through September and will be tested for Aquashade® (Acid Blue 9 and Acid Yellow 23) the colorant that will be used in the lakes to help control the growth of vegetation. The dyes in Aquashade® are not filtered out when moving through fine grained soils so the presence of these dyes in any of the monitoring wells would be indicative of leakage.

2.2 Additional Monitoring

a. The flowmeter on the lake fill line will be read and recorded on a weekly basis from April through September and then on a monthly basis from October through March.

b. The lake level transducer will be read and recorded on a weekly basis from April through September and then on a monthly basis from October through March.

c. Temperature and precipitation data will be kept daily throughout the water ski season.

2.3 Who Performs Monitoring

Initially, the above-described monitoring will be the responsibility of Carver Engineering until at such time Rosewater maintenance personnel can be trained to do the work.

3.0 LEAK DETECTION

It must first be pointed out and be clearly understood, that based on the type and thickness of the liner material used at Rosewater, installation of the liner by authorized representatives of the liner manufacturer with testing of all factory and field seams, and the fact that soils on which the liner was installed and soils used to cover the liner contained no rock fragments of any size and are essentially ideal for liner installation, leakage through the installed Rosewater liner is extremely remote. The 30 mil PVC has a manufacturer's warranty of 20 years; however, it is fully expected that the liner will provide trouble-free containment of water in the Rosewater lakes for many years longer. (Refer to Subsection 1.2.1 – Longevity of PVC Liners in this Manual as well as the studies in Appendix B). It is also important to note that the liner was covered with 18" of fine grained, gravel-free soil, more than the 12" of cover recommended by virtually all liner manufacturers and suppliers, which will provide added protection against accidental damage to the liner.

As previously mentioned, Aquashade® will be used to control the growth of vegetation in the lakes and the presence of the dyes in Aquashade® in any of the monitoring wells will indicate that leakage has or is occurring at some location in the lakes. The location of the monitoring well in which the dye was observed, along with direction of groundwater flow, will give some general understanding of the location of a leak; however, beyond that, it will be necessary to employ a professional liner leak detection

firm to determine the exact location of the leak and to establish the magnitude or size of the leak.

3.1 Description

Leaks through geomembranes, e.g. PVC liners, can easily be detected, located and, in some cases, quantified by the electrical leak location method. The principal behind this method is to apply voltage to an electrode in the soil or water covering the liner and then locate where the electrical current flows through a leak or leaks in the liner. The premise behind the technology is simple: "Where the water goes – the electricity flows".

There are several companies specializing in leak detection through geomembranes, but hydroGEOPHYSICS (HGI), of Tucson, AZ, has developed a floating cable array system with multiple transmitting electrodes that can be stretched across a pond or lake and be slowly pulled along the full length of the lake. A color-coded map can be generated showing the location(s) of any leaks. The lakes can be filled to maximum capacity prior to conducting the leak detection survey which allows for a complete survey of potential leaks along the slopes and bottom in just a single setup. With water and soil covered liners like that at Rosewater, leaks as small as 0.04 square inch can be detected.

3.2 If a Leak Is Detected

If a leak is detected by a leak detection survey, as described above, the location of the leak and the approximate magnitude of the leak will have been determined by the mapped survey results. For relatively small leaks up to 1/2" in size, an environmental soil sealant (ESS-13) shall initially be applied.

ESS-13 is a product sold and applied by Seepage Control, Inc., of Chandler, AZ, and after determining the proper application rate, the soil sealant material can be applied with water still in the lakes. ESS-13 is a colloidal dispersion of oil in water and works by reducing the hydraulic conductivity of the soils by filling voids in the soil and by chemically and electrically modifying the alignment of clay platelets in the soil. After application of ESS-13, which may take 24 to 48 hours to be effective, an electrical leak detection survey shall again be conducted to determine the effectiveness of the ESS-13 application. If significant leakage is still detected, physical repair of the liner, as described below, will be necessary.

3.3 Lowering the Water Level & Fixing Leaks

The north and south lakes can be isolated from one another by using portable dams – AquaDam, FlexiDam, Aqua-Barrier, or equal – at the west end of the lakes. Then only the water level in the lake with the leak will be lowered. ***It should be pointed out that lake water will not be drained or pumped back to the Whitefish River to lower lake water level.***

a. A leak within 2'-0" of the normal high water level (HWL) will be repaired by first shutting the valve on the water fill line to the leaking lake and allowing the water level to fall to the leak elevation by evaporation, drawing water for irrigation and/or by continued seepage through the leak. If the water level

in the non-leaking lake is below that lake's HWL, water can be pumped from the leaking lake to the non-leaking lake.

Localized damming can then be employed at the leak and cover soil can be removed to expose the liner. The liner will then be repaired by an authorized representative of the liner manufacturer or someone working under the guidance of the liner manufacturer.

b. A leak below 2'-0" from the HWL will be repaired by same methods as described above; however, a temporary pump and irrigation system will be provided to more quickly lower the water level. This water will be applied to non-irrigated Common Areas H and/or I.

Water will applied at historic crop irrigation rates and irrigation will be monitored to preclude surface runoff. As a precaution, erosion control BMP's will be installed along any drainage within 200 ft. of the top of bank along the east side and southeast corner of the Rosewater property.

4.0 VEGETATION CONTROL

The control of vegetation in and around the Rosewater lakes is important for water quality reasons and for aesthetics. The lakes are an extremely important asset to the Rosewater community and proper care of the lakes is essential.

4.1 Colorants

Colorants are concentrated dyes used to give an aesthetically pleasing appearance to water and to control the growth of vegetation. Aquashade®, mentioned several times in this O&M Manual, will be used in the Rosewater lakes for those reasons. Aquashade® is a blend of blue and yellow dyes which shades specific portions of the sunlight spectrum (red-orange and blue-violet) required by underwater aquatic plant and algae for growth. This shading inhibits photosynthesis in young, bottom growth.

Although not for use in human drinking water, there are no restrictions for animal/livestock drinking, irrigation, swimming or fish consumption when used at recommended rates. Aquashade® is registered by the EPA for use in natural and man-made contained lakes and ponds (ornamental, recreational, fish rearing & fish farming bodies) with little or no outflow of water.

The recommended application rate for Aquashade® is 0.25 gallon per acre-ft. There is approximately 153 acre-ft of water in the Rosewater lakes, so a total of 38.25 gallons of Aquashade® would be needed for the initial application. As new water is added to the lakes, to replace water that has evaporated or has been used for irrigation, additional Aquashade® will have to be applied to maintain adequate levels of colorant. Aquashade® is self-dispersing and can be applied by pouring it along the shoreline and/or from a boat.

4.2 Algaecides

Algae are small organisms which can spread rapidly through flowing water, wind or on living organisms. Algae can cause cloudy water, scum on the water surface, or thick mats that can be floating or underwater. There are many different algaecide products available and it is very important to first identify the type or types of algae that need to be controlled before selecting the algaecide to be used.

It is strongly recommended that Rosewater operating and maintenance personnel obtain a copy of, "*How to Indentify and Control Water Weeds and Algae*". The manual can be downloaded from the Applied Biochemists web site at: appliedbiochemists.com.

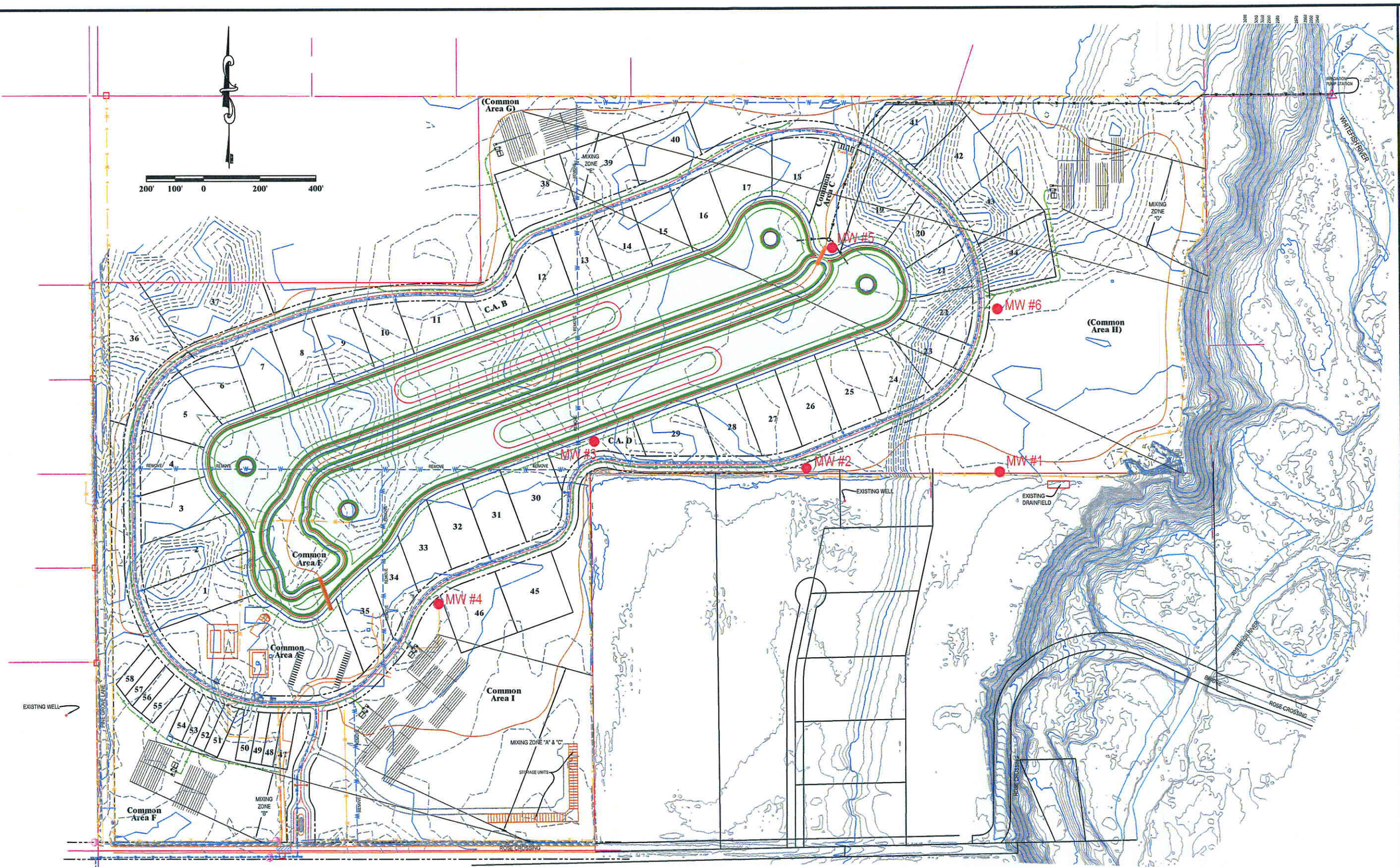
4.3 Herbicides

As with algaecides, there are numerous herbicide products available. Controlling aquatic plant growth can be difficult because most often the plant must be identified properly before it can be correctly treated. As mentioned above, a copy of "*How to Indentify and Control Water Weeds and Algae*" is recommended for operating and maintenance personnel at Rosewater.

5.0 FUNDING OF OPERATION & MAINTENANCE

Funding of operation and maintenance of the Rosewater lakes, and other Rosewater improvements and amenities, is the responsibility of the Rosewater Homeowner's Association (Rosewater HOA). Adequate monthly or annual O&M fees must be collected to fund, not only operation and maintenance of the water ski lakes, but also groundwater monitoring and sampling, maintenance of Common Areas, irrigation systems, road maintenance and all other Rosewater amenities.

Score Management, LLC, owner and developer of Rosewater, will contribute an adequate amount (initially $10,000) of "seed money" for the Rosewater HOA to help start a funding pool for their O&M responsibilities.



DIRECTION OF PERCHED GROUNDWATER FLOW: SOUTH 20° EAST

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Revision(s)
12/4/2012

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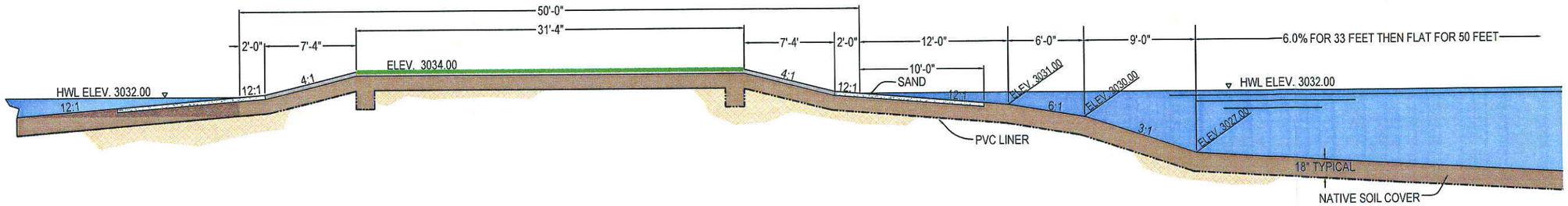
Project Title
ROSEWATER SUBDIVISION

Sheet Title
MONITORING WELLS

FIGURE 1



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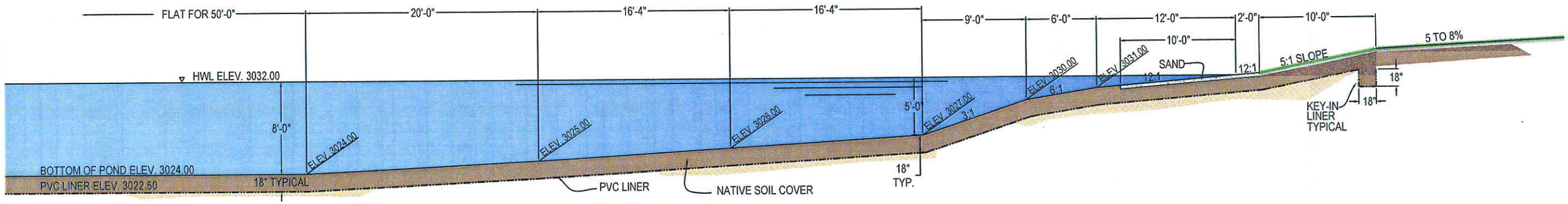

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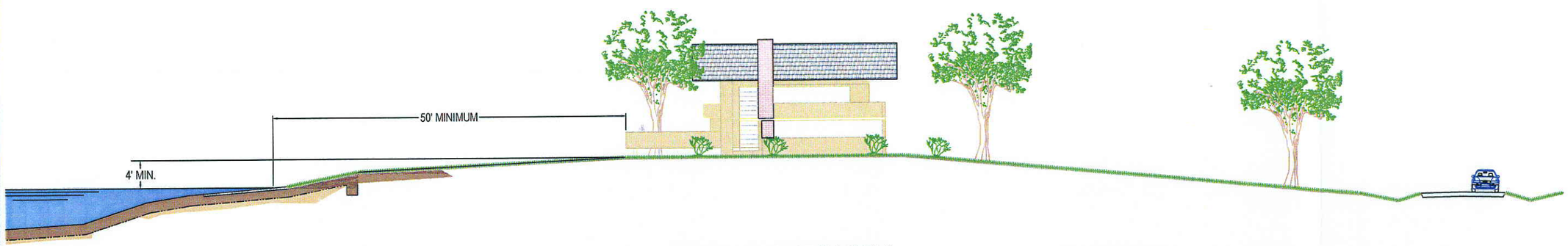

TYPICAL LOT SECTION DETAIL
SCALE: NONE

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ROSEWATER SUBDIVISION

Sheet Title
CROSS SECTIONS OF LAKES & LOTS

FIGURE 2

Appendix A

30 Mil PVC Specification

Certified Properties	Test Method	Requirement
Thickness ±5%	ASTM D 5199	.030"
Tensile - lb. force/in. width, min.	ASTM D 882	73
Elongation at Break (%, min.)	ASTM D 882	380
100% Modulus- lb. force/in. width, min.	ASTM D 882	30
Tear Strength (lb./in., min.)	ASTM D 1004	8
Dimensional Stability (% change max.)	ASTM D 1204	3
Impact Cold Crack (°C)	ASTM D 1790	-29
Index Properties		
Specific Gravity (min.)	ASTM D 792	1.20
Water Extraction (%, max.)	ASTM D 1239	0.15
Volatile Loss (%, max.)	ASTM D 1203(A)	0.70
Resistance to Soil Burial (% change max.)	ASTM G 160	
1. Breaking Factor		5
2. Elongation at Break		20
3. Modulus at 100% Elongation		20
Hydrostatic Resistance (psi, min.)	ASTM D 751(A)	100
Plasticizer Min. Ave. Molecular Weight	ASTM D 2124	400
Minimum Specifications for EPI Factory Fabricated Seams:		
Peel Strength, lbs/in. width	ASTM D 7408	15
Shear Strength, lbs/in. width	ASTM D 7408	58.4

SECTION 02770

PVC GEOMEMBRANE

PART 1 GENERAL

1.1 SECTION INCLUDES

A. The GEOSYNTHETICS CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the installation of all geomembrane, complete with appurtenances, as shown, specified or required by the Drawings.

1.2 RELATED SECTIONS

A. Section 02278 – Geosynthetic Clay Liner

B. Section 02595 – Geotextile

C. Section 02599 – Geocomposite Drainage Layer

1.3 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. D 618 Conditioning
2. D 751 Hydrostatic Burst Test, Section 33, Procedure A
3. D 792 Specific Gravity
4. D 882 Tensile Properties
5. D 1004 Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting
6. D 1203 Volatile Loss
7. D 1204 Dimensional Stability
8. D 1239 Water Extraction
9. D 1790 Low Temperature Impact
10. D 4354-99 Standard Practice for Sampling of Geosynthetics for Testing
11. D 4551 PVC Plastic Concealed Water Containment Membrane
12. D 4873-01 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples

13. D 5199-01 Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
14. D 5321-92 (1997) Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
15. D 5820-95 Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes
16. D 6214 Chemical Seam Evaluation
17. D 6243-98 Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method
18. D 6392-99 Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
19. D 7176 Standard Specification for Non-Reinforced Polyvinyl Chloride (PVC) Geomembranes used in Buried Applications.
20. D 7177 Standard Specification for Air Channel Evaluation of Polyvinyl Chloride (PVC) Dual Track Seamed Geomembranes

B. Environmental Protection, Inc.
   1. Quality Control Manual for Fabrication and Installation of PVC Geomembranes. January 1, 2006.

C. The most current version of the specified test method shall be followed by the MANUFACTURER, GEOSYNTHETICS CONTRACTOR or authorized testing laboratory.

1.4 DEFINITIONS

A. Minimum Value – Property value representing the lowest individual allowable value obtained when tested according to the specified test method. This applies to individual readings, such as thickness; or where only one specimen is tested for the specified parameter.

B. Minimum Average Value – Property value representing the lowest allowable value for the average of results for the specimens tested.

C. Nominal Value – Property value that is representative of a measurable property, determined under a set of prescribed test conditions, by which a product may be described.

D. Lot - For the purposes of this project, a "Lot" will be defined as a single run of geo synthetic material from the same production facility, where the tooling and raw materials of production have not changed during manufacturing.

E. Roll - A quantity geomembrane rolled up to form a single package as supplied from the manufacturer

F. Sheet - A part of the manufactures geomembrane material cut from the roll.

G. Panel - A series of geomembrane sheets fabricated together to make a larger unit, as supplied by a fabricator usually folded onto a pallet or folded then rolled on a core.

H. Manufacturer - A company that takes raw materials and calendars or extrudes them into geomembrane rolls

I. Fabricator - a company that converts geomembrane rolls into panels

J. Installer – a company that installs PVC geomembrane panels in field applications.

1.5 SUBMITTALS

A. The GEOSYNTHETICS CONTRACTOR shall submit to the ENGINEER all items included in this Article. Submittals shall be provided as follows:

1. With the GEOSYNTHETICS CONTRACTOR's BID:
    a. A project reference list documenting the experience of the GEOSYNTHETICS CONTRACTOR on a minimum of 5 projects consisting of at least 10 million square feet of installed PVC geomembrane.
    b. A copy of the Fabricator's Quality Assurance/Quality Control (QA/QC) Plan for the complete geomembrane fabrication process.
    c. A schedule of operations, including means and methods of installation.
    d. The name of the fabricator of the geomembrane panels to be used for the project and the proposed method of joining adjacent geomembrane panels.
2. At least 15 days prior to delivery of geomembrane to the site, unless otherwise noted below:
    a. Shop drawings, including proposed panel diagram and details of proposed work, pipe boots, and details of sealing around all necessary geomembrane penetrations, to be submitted at least 15 days prior to delivery of geomembrane to the site. The panel

diagram must depict and/or note the planned number and orientation of panels, the panel sizes, seam orientation, placement of seams in corners, treatment of tee seams and the GEOSYNTHETICS CONTRACTOR's preferred sequence of panel placement. The PVC panels shall be orientated in a manner that minimizes seams. The ENGINEER, prior to geomembrane installation must approve the panel diagram. The ENGINEER, in writing, prior to altering the installation, must approve proposed revisions to the panel diagram.

b. Geomembrane - Manufacturing Quality Control (MQC) data (Material Certifications) for the geomembrane to be delivered to the site. The reports shall include the quality control test results obtained during the manufacture of the material. In the event material is delivered to the site prior to the receipt of the MQC certificates, the material without certificates will be stored separately from the material with certificates. Material with unacceptable MQC data will be segregated from approved material and shall be marked for rejection. The geomembrane will be rejected if it is found to have defects, rips, holes, flaws, deterioration or other damage deemed unacceptable by the ENGINEER.

c. Geomembrane Sample - Samples of the proposed geomembrane shall be sent to the OWNER for interface shear testing within 5 days after the OWNER makes such request. The GEOSYNTHETICS CONTRACTOR shall coordinate the quantity and dimensions of the samples with the OWNER.

3. At least 15 days prior to installation:

a. Resumes of geomembrane crew; including, Supervisor, QC Manager, and Master Seamer. The resumes shall include prior experience in installing PVC geomembrane. Individual geomembrane crew members will be subject to the approval of the ENGINEER and OWNER.

b. A copy of the GEOSYNTHETICS CONTRACTOR's standard operating procedure (SOP) for operating an ATV on site,

particularly with respect to specific uses of the ATV and the prevention of damage to materials.

c. Field tensiometer calibration certificate showing that the equipment to be used for shear/peel testing in the field has been calibrated by a qualified individual within the previous 6 months.

4. During Installation Submitted Daily:
   a. Completed Subgrade Acceptance Form, as endorsed by the ENGINEER, prior to geomembrane deployment in any area.
   b. Construction progress reports clearly showing geomembrane placed by date.
   c. Passing and failing test results for trial seams.
   d. Documentation of passing and failing destructive and non-destructive testing of installed seams.
5. Within 5 days after completion:
   a. Summary and log of all field quality control work completed by the GEOSYNTHETICS CONTRACTOR.
   b. Certification statement signed by the Supervisor that geomembrane installation is complete and in accordance with these Specifications, with details of any changes or exceptions noted.
   c. Statement of material and installation warranties.

B. The above-noted requirements shall apply to all shop-fabricated materials and those items specified for fabrication in the field.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. The GEOSYNTHETICS CONTRACTOR shall protect the work described in this Section before, during, and after installation, and shall protect the installed work specified in other Sections, as well as work completed by the OWNER.

B. Geomembrane labeling, shipment and storage shall follow ASTM D4551 as modified according to this Specification.

C. Product labels shall be placed on the top of panels such that they can be seen, clearly showing the fabricator or supplier name, product description, panel number, and panel dimensions.

D. Each panel of PVC shall include any additional information required to allow the ENGINEER to relate that panel with the manufacturing quality control and raw material quality assurance documentation. Additionally, if any special handling is required, it shall be so marked on the outside surface of the wrapping.

E. During storage, the geomembrane shall be placed on a stable, relatively flat, dry, well-drained surface. The geomembrane pallets shall not be placed on objects that may cause deformation of the geomembrane panels. Adequate space shall be left between stored panels, such that panel labels can be examined. The geomembrane shall be protected from the following:

1. Site construction damage.
2. Chemicals that are strong acids or bases.
3. Flames, sparks, geomembrane temperatures in excess of 150° F.
4. Any environmental condition that might damage the geomembrane.

F. Panel numbers on partially used panels must be maintained such that each panel number can be readily identified prior to deployment of the remaining portions of the panel.

G. If the ENGINEER determines the geomembrane is damaged, the GEOSYNTHETICS CONTRACTOR shall make all repairs and replacements in a timely manner, so as to prevent delays in the progress of the work.

PART 2 MATERIALS

2.1 GENERAL

A. The geomembrane sheet shall consist of polyvinyl chloride (PVC) resin in amounts greater than 50% of the total polymer content suitably compounded with plasticizers, stabilizers, additives, and pigments, to satisfy the physical property requirements.

B. The ENGINEER shall conduct conformance testing on the geomembrane. The GEOSYNTHETICS CONTRACTOR shall, at no additional cost to the OWNER, provide whatever reasonable assistance the ENGINEER may require in obtaining samples for conformance testing. Geosynthetic material sampling frequency shall be in accordance with ASTM D4354, unless determined otherwise by the ENGINEER. A qualified laboratory with GAI-LAP accreditation shall conduct conformance testing.

C. Conformance testing will be at the expense of the OWNER, unless the tests show the material does not comply with the Specifications, in which case the GEOSYNTHETICS CONTRACTOR shall pay the cost of re-sampling and testing.

D. The GEOSYNTHETICS CONTRACTOR shall be solely responsible for the quality of the material provided. Should any of the tests performed on the material yield unsatisfactory results, the GEOSYNTHETICS CONTRACTOR will be responsible for replacing the material with satisfactory materials without delay to the project or cost to the OWNER.

2.2 GEOMEMBRANE

ASTM D7176 Standard Specification for Non-Reinforced Polyvinyl Chloride (PVC) Geomembranes used in Buried Applications.

Certified Properties	**ASTM**	**PVC 10**	**PVC 20**	**PVC 30**	**PVC 40**	**PVC 50**	**PVC 60**
Thickness	D 5199	10 ±0.5 mil 0.25±.013mm	20 ±1 mil 0.51 ± .03 mm	30 ±1.5 mil 0.76 ± .04 mm	40 ±2 mil 1.02 ± .05 mm	50 ±2.5 mil 1.27 ± .06 mm	60 ± 3 mil 1.52 ± .08 mm
Tensile Properties[2]	D 882 Min						
Strength at Break		24 lbs/in 4.2 kN/m	48 lbs/in 8.4 kN/m	73 lbs/in 12.8 kN/m	97 lbs/in 17.0 kN/m	116 lbs/in 20.3 kN/m	137 lbs/in 24.0 kN/m
Elongation		250%	360%	380%	430%	430%	450%
Modulus at 100%		10 lbs/in 1.8 kN/m	21 lbs/in 3.7 kN/m	32 lbs/in 5.6 kN/m	40 lbs/in 7.0 kN/m	50 lbs/in 8.8 kN/m	60 lbs/in 10.5 kN/m
Tear Strength	D 1004 Min	2.5 lbs 11 N	6 lbs 27 N	8 lbs 35 N	10 lbs 44 N	13 lbs 58 N	15 lbs 67 N
Dimensional Stability	D 1204 Max Chg	4%	4%	3%	3%	3%	3%
Low Temperature Impact	D 1790 Pass	-10° F -23° C	-15° F -26° C	-20° F -29° C	-20° F -29° C	-20° F -29° C	-20° F -29° C

Index Properties	**ASTM**	**PVC 10**	**PVC 20**	**PVC 30**	**PVC 40**	**PVC 50**	**PVC 60**
Specific Gravity	D 792 Typical	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc
Water Extraction Percent Loss (max)	D 1239 Max Loss	0.15%	0.15%	0.15%	0.20%	0.20%	0.20%
Volatile Loss	D 1203 Max Loss	1.5%	0.9%	0.7%	0.5%	0.5%	0.5%
Soil Burial	G 160 Max Chg						
Break Strength		5%	5%	5%	5%	5%	5%
Elongation		20%	20%	20%	20%	20%	20%
Modulus at 100%		20%	20%	20%	20%	20%	20%
Hydrostatic Resistance	D 751 Min	42 psi 290 kPa	68 psi 470 kPa	100 psi 690 kPa	120 psi 830 kPa	150 psi 1030 kPa	180 psi 1240 kPa

Seam Strengths	**ASTM**	**PVC 10**	**PVC 20**	**PVC 30**	**PVC 40**	**PVC 50**	**PVC 60**
Shear Strength[2]	D-882 Min	20 lbs/in 3.47 kN/m	38.4 lbs/in 6.7 kN/m	58.4 lbs/in 10 kN/m	77.6 lbs/in 14 kN/m	96 lbs/in 17 kN/m	116 lbs/in 20kN/m
Peel Strength[2]	D-882 Min	10 lbs/in 1.8 kN/m	12.5 lbs/in 2.2 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m

***FTB = Film Tearing Bond *MD = Machine Direction *TD = Transverse Direction**

Notes:
1. Certified properties are tested by lot as specified in ASTM D-7176.
2. Metric values are converted from US values and are rounded to the available significant digits.
3. Modifications or further details of test are described in ASTM D-7176.
4. Index properties are tested once per formulation as specified in ASTM D-7176.

A. Geomembrane Conformance Testing - The ENGINEER shall take samples of the geomembrane panel for conformance testing. Unless otherwise specified, samples shall be three feet long by the roll width and shall not include the outer

wrap. The ENGINEER or authorized representative shall mark the machine direction on the samples with an arrow.

1. Unless otherwise specified, conformance samples shall be taken at a rate of one per 100,000 square feet. An appropriate number of samples, as determined by the ENGINEER in accordance with ASTM D4354 will be taken. The ENGINEER will ship these samples directly to the CQA laboratory.
2. Geomembrane conformance samples selected by the ENGINEER may be tested for any properties specified in Article 2.3, but shall as a minimum be tested for the following:

GEOMEMBRANE CONFORMANCE
MINIMUM TESTING AND FREQUENCY

PROPERTY	TEST METHOD	
Thickness	ASTM D 5199	
Strength at Break	ASTM D 882	
Elongation	ASTM D 882	
Modulus at 100%	ASTM D 882	
Tear Strength	ASTM D 1004	
Low Temperature	ASTM D 1790	

3. Non-conforming material will not be used in the work. In the event non-conforming results are obtained from the laboratory, the nearest numbered rolls on each side of the non-conforming roll shall be sampled and tested for the full suite of conformance tests, until the extent of non-conformance is established, at no cost to the OWNER. The owner reserves the right to reject the lot of rolls at any stage of extended sampling and testing.

E. Interface Shear Testing - Interface shear strength testing of the geomembrane and related materials is the responsibility of the OWNER. The results must comply with the criteria determined by the OWNER, as specified in the Construction Drawings. All testing must meet the minimum requirements, and the analysis of those results must be completed by the ENGINEER prior to installation of the materials. Testing for geosynthetic to

geosynthetic, or geosynthetic to soil interface, shall be conducted according to the current version of ASTM D 5321-92 (97). Testing for interfaces involving geosynthetic clay liner (GCL) shall be conducted according to the current version of ASTM D 6243-98.

2.5 FACTORY FABRICATION

A. All completed factory seams are 100% inspected. Factory seams will be visually inspected for full seam continuity over their full length. Any areas that do not meet the specified requirements shall be removed and repaired per section.

B. Destructive tests will be performed to verify that the seam strength requirements of the specifications are met. Random samples shall be taken at a minimum of every 3,000 lineal feet of factory seam or once per factory panel fabricated, which ever is more frequent, and the following quality assurance tests will be performed on each sample:

   a. Thickness
   b. bonded seam strength (shear strength)
   c. peel adhesion

C. The sample shall be cut into ten one - inch wide specimens. Five peel and five bonded seam specimens are removed. Five specimens shall be tested for bonded seam strength (bss) and five for peel adhesion. To be acceptable, the average of five test specimens for peel and the average of five test specimens for bonded seam strength must meet the minimum peak load requirements of factory seams as follows:

   a. Bonded Seam Strength: One-inch strips cut with the weld centrally located are tested by stressing the weld in a "shear" configuration. That is, the top sheet is stressed in relation to the bottom sheet in a direction away from the weld. A pass result occurs when the specimen averages meet the minimum peak load requirements stated in the contract (usually 80% of specified sheet strength). A failure occurs when the weld separates or the material breaks at a peak load less than the minimum requirements. The test result to be reported will be the average of the peak loads recorded for each of the five specimens.

   b. Peel Adhesion: One-inch strips cut with the weld centrally located are tested by stressing the top sheet in relation to the overlapped edge of the lower sheet in an effort to peel the weld away. Each specimen will be peeled one

inch along the seam length. A pass result occurs when the specimen meets the minimum peak load requirements stated in the contract. A failure occurs when the weld peels at a peak load less than the specification without film tearing bond. The test result to be reported is the average of the peak loads recorded for each of the four specimens.

D. Each test will be identified by panel serial number and the manufacturer's roll number. These tests shall be performed in the fabricators laboratory.

E. Prior to installation of the geomembrane at the site, the fabricator will provide to the ENGINEER, copies of manufacturer material certifications and a copy of quality control test results for all panels to be supplied, verifying conformance with this specification and the requirements as represented in ASTM D 7176 specification. The location of any defects and repairs and all necessary retesting results will also be documented in the report.

F. When a seam sample is removed from the panel being fabricated the resulting hole will be repaired with a patch with a minimum of a one inch bonded area around the patch, and the patch will be rounded on all corners.

G. Factory fabricated geomembrane panels are packaged accordion folded on a sturdy wooden pallet designed for fork lift truck access. Smaller panels (i.e. less than 500 lbs.) can be rolled on a fiber core, and placed on a pallet.

H. All panels will be packaged with a protective, black stretch wrap or cardboard cover to protect the panel from weather or shipping damage.

2.6 GEOMEMBRANE PENETRATION BOOTS

A. The GEOSYNTHETICS CONTRACTOR shall furnish all geomembrane penetration boots and other materials required for completion of the geomembrane installation. All geomembrane boots required for the project shall be factory pre-fabricated boots. The geomembrane shall be of the same thickness as the geomembrane panels.

B. Geomembrane penetrations are to be constructed only at the locations shown on the Plans. The GEOSYNTHETICS CONTRACTOR is cautioned that no deviation in the quantity or configuration of geomembrane penetrations will be accepted without the advance written approval of the ENGINEER.

C. All penetrations through the geomembrane shall be thoroughly and securely sealed. The seal between the geomembrane and the pipe shall be without any detectable leakage.

D. In attaching the geomembrane penetration boot in the field, no field seams will be allowed in locations or configurations that do not allow for Construction Quality Control testing. Visual observation is not considered a sole acceptable method for in-field quality control.

E. Where clamps, fasteners, gasket seals or sealants are used, the GEOSYNTHETICS CONTRACTOR shall use only materials that are compatible with the geomembrane.

PART 3 EXECUTION

3.1 SITE PREPARATION

A. All required grading, grooming and construction quality assurance (CQA) testing on any low permeability soil or GCL to be covered by the geomembrane shall be complete and accepted by the ENGINEER prior to geomembrane placement.

B. The surface to be covered by the geomembrane shall be cleared of sharp objects, angular stones, sticks, or any materials that may contribute to punctures, shearing, rupturing or tearing of the geosynthetic materials. The geomembrane subgrade shall have a smooth, finished surface, free from pockets, holes, ruts, and discontinuities that, in the judgment of the ENGINEER, will cause bridging of the material. The subgrade shall be inspected for unsuitable areas or soft spots before the geomembrane is placed, and additional surface preparation will be required to eliminate any unsuitable areas as determined by the ENGINEER.

C. The GEOSYNTHETICS CONTRACTOR and ENGINEER shall carefully and completely inspect the subgrade surface immediately prior to the deployment of each geomembrane panel. No geomembrane shall be placed on unsuitable subgrade surface, or without the ENGINEER's written approval. The ENGINEER and the GEOSYNTHETIC CONTRACTOR's Quality Control (QC) inspector shall furnish their signatures on a Subgrade Acceptance Log prior to the installation of each panel or series of panels placed on a daily basis.

D. Under no condition shall the geomembrane be placed over standing water on the subgrade.

3.2 SEAMING METHODS

A. A six - inch wide overlap must be cleaned of all dust, dirt or foreign debris no more than 30 minutes prior to welding. Only clean, soft rags will be used for cleaning. If mud has adhered to the sheet surface overlap area, it will be removed with clean water and allowed to dry prior to seaming.

B. During the cleaning operation, the sheet will be inspected for defective areas which must be removed and/or repaired prior to seaming. The seaming operation requires a solid, smooth subsurface. Subsurface voids, hard nodules, rocks, soft areas or unsuitable conditions will be removed or repaired prior to seaming during subgrade preparation.

C. Seaming cannot be conducted in the presence of standing water. Wet surfaces must be allowed to dry. A slip sheet or seaming board may be used to lift the geomembrane above damp surfaces. If wind conditions contaminate the seaming area or displace the geomembrane sheets, temporary ballast and additional cleaning procedures will be required.

D. The geomembrane panels shall be joined utilizing approved seaming methods. Dual-track fusion welding shall be the required method on all seams where it is feasible. Chemical welds shall be made only where approved by the ENGINEER.

E. All geomembrane surfaces that are to become a seam interface are to be free of dust, dirt, excess moisture or any other condition that may affect the quality of the seam.

F. Seaming will not be allowed during rain or snowfall, unless proper precautions are made to allow the seam to be made on dry subgrade and geomembrane materials. If weather conditions are not satisfactory, panels will not be put into place. If panels are placed and pulled out, the installation crew will do what is necessary to finish or secure those individual panels that day.

G. The field seams shall be produced using one of the following methods:

1. Dual-Track Thermal Fusion Weld – All field seams shall be fused using Dual-Track Thermal Fusion Welding. A seam produced by melting the two intimate surfaces by running a hot metal wedge or hot air device between the surfaces, followed immediately by pressure to form a homogeneous bond. This seam has a center air channel for non-destructive testing of the seam.

Panels to be seamed shall be overlapped sufficiently to allow proper destructive testing of seams. The CONTRACTOR shall mark the liner where the Dual-Track Fusion Welding machine settings are adjusted (including speed, temperature and pressure). Measurable setting values shall be indicated on the liner.

2. Chemical Fusion Weld – Chemical Fusion Welding shall only be used for repairs and detail work. All field seams will be a minimum of 2 inches wide. A sufficient amount of chemical fusion agent will be applied that, upon compressing the seam surfaces together, a thin excess of chemical fusion agent will be forced out. A high durometer rubber, nylon or steel roller will be used to compress the seam surfaces together until a bond is formed. Roller action will be at a parallel direction to the seam's edge so that excessive amounts of chemical fusion agent will be purged from between the sheets. Trapped chemicals should be rolled out of the seaming area. Care will be exerted in applying the chemical fusion agent. A continuous wet layer of chemical fusion agent is necessary to prevent a leak at the tie - in point between the last chemical fusion agent application and the next. If the chemical fusion agent, which is initially shiny when applied, takes on a dull filmy appearance, the interfaces may require a faster closing together or the ambient temperature is too high to continue seaming. The installer will monitor this condition at sheet temperatures over 105°F. At the completion of seaming, all rags, chemical containers, etc., will be properly removed from the geomembrane.

3.3 INSTALLATION

A. The number of panels to be deployed in any day will be limited to the number of panels which can be seamed that day. The geomembrane will be placed over the prepared surface in such a manner as to assure minimum handling.

B. Based on the approved geomembrane panel diagram and material certifications, the individual panels will be numbered and seams will be identified by using the panel numbers that create the seam. The PVC panels shall be installed in a manner that minimizes seams. Where ever possible longitudinal seams shall be oriented to be no greater than ten degrees from parallel with the direction of the slope. Cross seams (i.e. those seams which join the ends of contiguous panels) shall not be placed on any slope that exceeds a ten percent grade. All panels

placed on slopes shall be cut no closer than five feet from the top of the slope or ten feet from the toe of slope. All seam overlaps shall be shingled in a downslope direction. In no case shall parallel seams be placed within five feet of the centerline of any leachate collection pipe.

C. During installation, and any other period of exposure of geomembrane, pedestrian and equipment activity over the geomembrane shall be kept to a minimum, and restricted to only that which is necessary for geomembrane construction.

D. Smoking is not permitted on the geomembrane.

E. Construction workers shall take precautions not to damage the geomembrane surface. Construction workers shall wear smooth-soled footwear, and exercise care not to drag tools across the geomembrane surface. All large tools are to have smooth base plates or shoes. Construction and landfill staff shall be informed of the restricted access to areas of geomembrane placement by use of barriers and signs posted as necessary.

F. The GEOSYNTHETICS CONTRACTOR shall perform all activities of geomembrane construction in such a way as to avoid damage to the geomembrane. Any damage caused to the geomembrane by the GEOSYNTHETICS CONTRACTOR shall be repaired or the material replaced at the expense of the GEOSYNTHETICS CONTRACTOR.

G. No tracked or wheeled vehicles, other than low ground pressure ATVs as pre-approved by the ENGINEER, shall be permitted on the geomembrane prior to placement of adequate soil cover, as determined by the ENGINEER.

H. The GEOSYNTHETICS CONTRACTOR shall complete his work in a manner that will prevent water or wind from getting under the partially installed geomembrane. This could include, but is not limited to, installing sandbags along the leading edges. Should excessive moisture become trapped below the geomembrane, or should wind damage occur due to the negligence of the GEOSYNTHETICS CONTRACTOR, the GEOSYNTHETICS CONTRACTOR, at no extra cost to the OWNER, will be required to perform all work, including removing and replacing as much of the in-place geosynthetic material as the ENGINEER directs, to assure that the integrity of the geomembrane and the underlying subbase or geosynthetic clay liner (GCL) has not been compromised.

I. Seams shall be welded throughout the entire length of the panels during initial panel seaming.

J. Sandbags or other approved ballast shall be used to prevent bridging or material movement in areas such as toe of slope or near sumps. Ballast shall not be used to force the geomembrane into contact with the subgrade.

K. Special care shall be taken to prevent tensile stress in the geomembrane and geomembrane seams in all corners and grade changes.

L. The GEOSYNTHETICS CONTRACTOR shall exercise his best judgment and care to provide sufficient slack in the PVC geomembrane.

M. The geomembrane shall not be installed when ambient or sheet temperatures are below 32° F, when the sheet temperature exceeds 158° F, or when the air temperature is above 120° F unless the GEOSYNTHETICS CONTRACTOR demonstrates, to the satisfaction of the ENGINEER, that procedures can be implemented which will result in the proper installation and seaming of the geomembrane.

N. Adjacent geomembrane panels shall be allowed to reach essentially equivalent temperatures prior to seaming to avoid development of fishmouths.

O. If fishmouths are created at the seam overlaps, they shall be cut to achieve a flat overlap.

P. Geomembrane covering operations shall be performed in a manner that does not damage the geomembrane lining system. Geomembrane covering operations shall be performed only in the presence of a Construction Observer such that the condition and cleanliness of the geomembrane is observed at the time the material is covered, and any effects of the covering operation on the geomembrane lining system can be observed.

Q. Any use of ATV's on the site must be pre-approved by the ENGINEER. The GEOSYNTHETICS CONTRACTOR shall submit an S.O.P. describing how ATV's are to be used, if at all, in the deployment of geomembrane at the site. As a minimum, the following shall apply:

1. Any damage resulting from the use of ATV's, as determined by the ENGINEER, shall be repaired according to Article 3.3, at no additional cost to the OWNER. If repeated repairs are required as the result of the use of ATVs operating on geosynthetic material, further use of ATVs will be prohibited.

2. Any and all ATV's proposed to be used in the deployment of geosynthetics will be inspected by the ENGINEER. ATV's which are found to be leaking oil or fuel, or which in any other way exhibit the potential to damage the lining system components, will not be permitted.

3. Any oil or fuel which leaks onto geosynthetic materials shall be thoroughly removed (cleaned) by the GEOSYNTHETICS CONTRACTOR, or the geosynthetic material shall be replaced at the discretion of the ENGINEER, at no additional cost to the OWNER.

4. Re-fueling of ATVs on geosynthetic materials is prohibited.

5. ATVs shall have tires with low ground pressure, typically less than 5psi, and shall have shallow treads.

6. ATVs shall be operated by a single operator at speeds less than 5 mph.

7. Quick starts, stops, spinning wheels and sharp turns will not be permitted above any geosynthetic material.

3.4 REPAIRS

A. All geomembrane panels and seams shall be examined by the ENGINEER for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The geomembrane surface shall be clean at the time of examination. Each suspect location shall be repaired and all repairs shall be non-destructively tested.

B. Damaged geomembrane shall be removed and replaced with acceptable geomembrane if damage cannot be repaired to the satisfaction of the ENGINEER.

C. Any portion of the geomembrane, or any portion of a seam exhibiting a flaw or failing a destructive or non-destructive test, shall be repaired as follows:

1. Geomembrane patches shall be used for holes over 1/8 of an inch in diameter, tears, and contamination by foreign matter. Patches shall be constructed of the same geomembrane, and will be joined to the panel using adhesive or chemical fusion welding where possible.

2. Geomembrane patches or caps shall extend at least 6 inches beyond the edge of the defect or failed seam area, and all corners of material to be patched. The corners of the patch shall be rounded.

3. Geomembrane caps shall be used to repair failed seams that are left in-place. Seams that fail destructive or non-destructive testing may also be removed and replaced if determined necessary by the ENGINEER.

PART 4 FIELD QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

4.1 GENERAL

A. Before installation begins, and weekly thereafter (more often if determined necessary by the ENGINEER) project coordination meetings shall be held with the designated representative of the EARTHWORKS CONTRACTOR, GEOSYNTHETICS CONTRACTOR, ENGINEER and OWNER in attendance to review the following information:

1. Progress of the work.
2. Adherence to the Specifications.
3. Adherence to the Construction Quality Assurance Program described in this Section, including the timely submission of the pertinent forms.
4. Planned work and methods for the ensuing week, including estimate of time remaining to completion of the work.
5. Problem resolutions to be implemented during the upcoming week.

B. All of the Forms specified and required must be submitted to the ENGINEER in a timely fashion.

C. The OWNER and ENGINEER must approve any changes in the proposed method of work, subcontractors to be utilized, geomembrane resin, or manufacturing in advance.

D. The GEOSYNTHETICS CONTRACTOR assumes all responsibility relevant to providing an acceptable product.

4.2 INSTALLATION QA/QC

A. The ENGINEER and GEOSYNTHETICS CONTRACTOR shall visually inspect all material to be included in the work, and compare panel identification numbers with those on the certifications provided by the manufacturer to assure delivery of the appropriate material.

B. Damage to geomembrane during installation shall be repaired according to Article 3.4. If the ENGINEER determines that any damage cannot adequately be repaired, the damaged material will be replaced.

C. The GEOSYNTHETICS CONTRACTOR will be required to conduct both destructive and non-destructive testing on seams during the geomembrane installation, as part of the Construction Quality Control program. All trial and installed seam samples shall be tested.

D. Thermal Weld Trial Seams –

1. Trial seams shall be produced each day, at the start of each workday, after every four hours of continuous operation, after each break in

seaming of 1 hour or more, after a break that results in equipment replacement or shutdown, and if the geomembrane temperature changes by more than 45°F. Trial seams shall be required each day for each piece of seaming equipment and each welding crew combination (including welding technician, seam cleaners and/or helpers). The trial seams will be performed on strips of geomembrane from approved rolls, and shall be produced at the work location such that the conditions mimic those under which production seams will be made.

2. A trial seam shall be a minimum of 5 feet in length for self-propelled seaming devices, and a minimum of 3 feet for hand-held seaming devices. The material for the trial seam and the test fixture for making the field tests shall be provided by the GEOSYNTHETICS CONTRACTOR at no additional cost. One-inch wide cutouts of the trial seams will be subject to shear and peel testing at the site. A minimum of 3 cutouts will be tested for shear, and a minimum of 3 cutouts will be tested for peel. The ENGINEER shall document the locus of break code for each specimen as shown in Figure 3 and Figure 4 of ASTM D6392-99, included at the end of this Section.

3. All trial seam specimens must be acceptable or the trial seam will be repeated until all results from a given trial seam are found acceptable. If any trial seam fails at any time during the workday, the reason for the failure shall be resolved before any production seaming of the geomembrane by the subject equipment and crew. All trial seam welding and testing must be observed by the ENGINEER.

4. A trial seam specimen will be considered a failure if:
   i. In the shear test, the bonded thickness of the seam fails or the material breaks at a stress lower than specified.
   ii. In the peel test, the two sheets comprising the seam separate at a peak stress lower than specified.

Should the ENGINEER, at any time during the installation, believe the production seaming process may not be performing adequately, he may, to avoid destructive sampling of the

installed geomembrane, request additional trial seams. The GEOSYNTHETICS CONTRACTOR at no additional cost shall do this.

E. The GEOSYNTHETICS CONTRACTOR shall complete non-destructive testing of all seams along their entire length, in the manner approved prior to installation, in the presence of the ENGINEER. The recommended test methods are as follows:

1. Pressurized Air Channel

   a. All field seams made by a dual-track fusion welding device will be tested by applying air pressure within the air channel to a sealed length of seam, and monitoring the pressure over time. The testing shall be conducted in accordance with ASTM D 7177.

   b. For the geomembrane, the initial inflation pressure shall be equal to or greater than the minimum according to ASTM D 7177. The minimum allowable pressure drop over a 30 second period shall be 5.0 psi.

   c. A pressure gauge shall be inserted into the end of the air channel to check for continuity in the air channel. Alternately, the far end of the seam may be cut to relieve the air pressure. An audible rush of air shall serve as an indicator that the test represents the entire length of seam.

   d. Air channels that do not hold the minimum specified air pressure shall be further inspected to identify the location and nature of any defects or unbonded sections of seam. The seam will then be repaired and retested. The ENGINEER may, at his discretion, require the entire questionable seam area to be capped or replaced.

2. Air Lance Testing

   a. The ENGINEER shall witness the testing, and the seam shall be clearly visible to the ENGINEER and GEOSYNTHETICS CONTRACTOR during the test. Unbonded areas or defects shall be marked by the ENGINEER for repair by the GEOSYNTHETICS CONTRACTOR.

   b. The air lance will be capable of supplying 50 PSI through a 3/16 inch diameter nozzle. The air stream is directed at the upper edge of the seam no more that 2 inches from the seam edge.

Any voids in the seam will be marked, repaired, and re-tested with the air lance. The testing technician and the inspector will mark each seam or repair with an indelible marker as accepted immediately after completion of final air lance testing.

F. All inadequate seams or portions thereof that fail the non-destructive testing shall be repaired in accordance with this Specification and the method approved by the ENGINEER. Should differences of opinion between the GEOSYNTHETICS CONTRACTOR and the ENGINEER develop during the installation relevant to seam integrity, the ENGINEER may, at his discretion, obtain samples of the seams in dispute for field and/or laboratory testing. The GEOSYNTHETICS CONTRACTOR will be responsible for patching the resulting void in accordance with the previously approved procedures at no additional cost to the OWNER.

G. Destructive Sample Collection - Samples of the in-place seams shall be cut from the installed geomembrane at a minimum frequency of one sample per 500 linear feet of seam, excluding repair seam length. A minimum of one seam sample shall be obtained for each seaming machine/operator combination for each day, or as directed by the ENGINEER. The cutout sections shall be 12 inches wide by 40 inches long with the seam centered lengthwise. The sample size can be reduced to 30" if the CONTRACTOR does not elect to have a cutout section for their use. A 1-inch wide specimen shall be cut from each end of the sample, and these two specimens shall be peel tested in the field in accordance with 4.2 G. The remaining sample shall be cut into 2 parts and distributed as follows:

1. One 12-inch by 18-inch sample to the ENGINEER for independent laboratory testing; and,
2. One 12-inch by 18-inch sample to the OWNER for archive storage.
3. The remainder of the sample shall be available for the CONTRACTOR if requested at the time of sample collection.

H. The 12-inch by 18-inch laboratory sample will provide 5 specimens for shear testing and 5 specimens for peel testing. Specimens that will be subject to peel and shear testing shall be selected alternately from the sample. All peel tests shall be performed on the outer track of dual track fusion welds. The laboratory shall report the locus of break code for each specimen according to the definitions included in Figure 3 and Figure 4 of ASTM D 6392, included at the end of this Section. The laboratory sample will be considered acceptable only if all 10

specimens meet the minimum requirements. The specimen will be considered a failure if:

1. In the shear test, the bond of the seam fails or the material breaks at a stress lower than specified.
2. In the peel test, the two sheets comprising the seam separate at a peak stress lower than specified. Complete peel separation of the seam is allowable.
3. In the shear or peel test, locus of break codes AD, AD-BRK, BRK, and SE are reported by the ENGINEER.

I. If a sample fails destructive testing, the welding path must be retraced to intermediate locations at least 10 feet in each direction from the location of the sample that failed the test, and a second sample shall be taken for an additional field test. If the tracking samples pass, the seam must be reconstructed between the location of the two tracking samples and the original sampled location. If the tracking sample fails, this process must be repeated. The seam between 2 passing test locations shall be capped, the cap seams shall be nondestructively tested, and shall include one field peel and shear test location along the reconstructed seam.

J. The ENGINEER and GEOSYNTHETICS CONTRACTOR shall visually inspect all geomembrane seams.

K. All welds shall be observed for traces of deformation to the geomembrane panels. Any seams, which in the opinion of the ENGINEER, have caused excessive deformation of the sheet, show signs of discoloration, exhibit thinning or stepping of the sheet, or show visual signs of overheating of the geomembrane panels, shall be repaired at no additional cost to the OWNER regardless of the result of any destructive testing on the seam. The deficient seam or portion thereof shall be cut out, the geomembrane panels again overlapped and seamed, or the questionable seam length shall be capped, as approved by the ENGINEER.

L. The GEOSYNTHETICS CONTRACTOR shall not place overlying materials on the installed geomembrane until the ENGINEER has reviewed and accepted the written test results for the geomembrane to be covered. At a minimum, the pre-delivery testing, the daily log of trial seam results, laboratory destructive sample results, non-destructive test results, record drawings of the completed area, and approval of the seams in place will be reviewed.

M. The GEOSYNTHETICS CONTRACTOR shall provide a report to the OWNER and the ENGINEER at the conclusion of the work which shall include the following:

1. The quality control tests used as specified and/or directed, including all requirements of the Report section of the specified test method.
2. Complete description of field sampling procedure, number of test specimens, size of test specimens.
3. Log of all Construction Quality Control work.

N. The GEOSYNTHETICS CONTRACTOR shall be responsible for all costs incurred by the OWNER including, but not limited to, additional field and laboratory CQA testing resulting from greater than 5 percent of the CQA testing not meeting or exceeding the Specifications.

O. All seams that cannot be subjected to the required Construction Quality Control or Construction Quality Assurance (CQA/CQC) testing shall be overcapped.

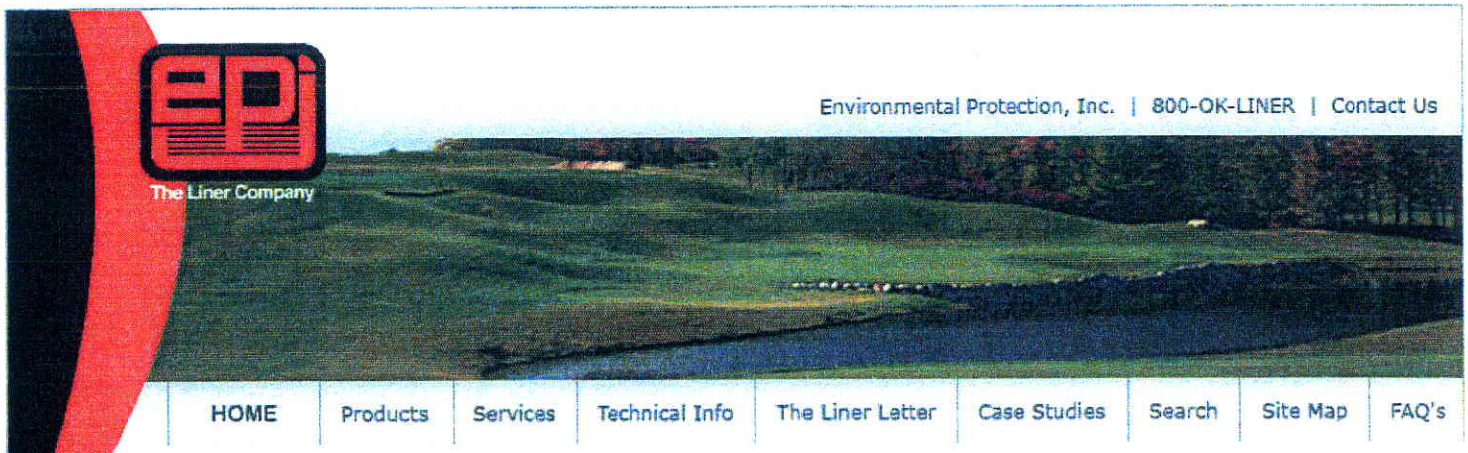
4.3 WARRANTY

A. The GEOSYNTHETICS CONTRACTOR shall issue a warranty on the installation of geomembrane for a minimum period of 1 year.

B. The GEOSYNTHETICS CONTRACTOR shall issue a warranty on the geomembrane material for a minimum period of 20 years.

END OF SECTION 02770

Appendix B

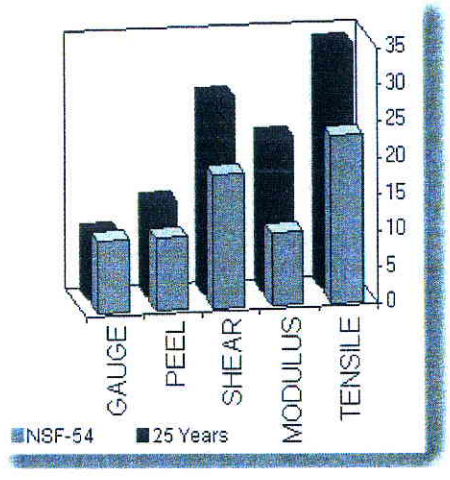


Installation
Thermal Welding
Durability
Case Studies
Solutions
Q-Control Manual
Published Papers

25 Year Old PVC Geomembrane

In the Spring of 1993 EPI provided a PVC liner for the enlargement of an irrigation pond at the Lakes of the North Golf Course in Northern Lower Michigan. During the excavation of the pond it was discovered that the original pond was lined with 10 Mil PVC Geomembrane.

In the process of excavating the pond the PVC Geomembrane was removed and a large number of material samples were recovered. These samples included both factory and field seams which were produced using a chemical fusion weld.



EPI contacted the office of Mr. Jerry Matthews, the golf course architect who originally designed the project, and learned that the original 10 Mil PVC liner was installed in the Summer of 1968. The liner was originally covered with twelve inches of sand, and approximately six to eight inches of silt had accumulated over the years on top of the sand cover.

EPI conducted physical property testing on the material and on the field and factory seams. Material samples were also forwarded to Occidental Chemical Corporation's Lab for analytical testing of the material. The PVC was still extremely flexible and extraction tests confirmed that placticizer still comprised 27% of the 25 year old PVC liner.

Elongation at break of the material was 267% which exceeds the original specifications of 250%. Peel testing of both factory and field seams resulted in a film tearing bond and all peel results were above the minimum requirement of 10 lbs. per inch width.

A comparison of other test results with today's NSF 54 minimum requirements for 10 Mil PVC is shown on the graph. 25 years of leak free, trouble free, maintenance free service, through freezing winters and scorching summers. Durable PVC liners provide decades of security for your containment needs.

30 Year Old PVC Geomembrane

By: Mark A. C. Wolschon & Fred P. Rohe

Michigan State University
W.K. Kellogg Biological Station
3700 East Gull Lake Drive
Hickory Corners, Michigan 49060

Click Here for research paper 30 yr Durability of 20 mil PVC Geomembrane

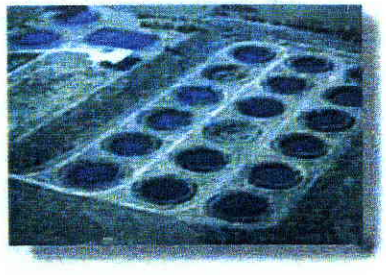
KBS Experimental Pond Facility

Eighteen 100 foot diameter research ponds were constructed in 1971 using 20 mil fish grade PVC geomembrane liner. The ponds are eight feet deep with slopes of three horizontal to one vertical. The PVC geomembrane was covered with one foot of sandy soil cover.

In order to start new experiments, nine ponds were cleared and rebuilt in 1987. In September 2000, the remaining nine ponds were cleared and re-lined with 20 mil fish grade PVC geomembrane liner. It is important to note that NONE of the ponds were leaking nor had any problems been observed with the PVC geomembrane liners. EPI fabricated 9 circular panels of 11,060 square feet each using Geon material from lot number 43464. The one piece liners were installed in ponds 4-8, 10, and 16-18, by Woolf Excavating of Kalamazoo, MI. who were contracted to clean and reline the ponds. On September 13, 2000 representatives from EPI removed samples of 30 year old 20 mil PVC geomembrane from the ponds.

Samples were removed from three main locations

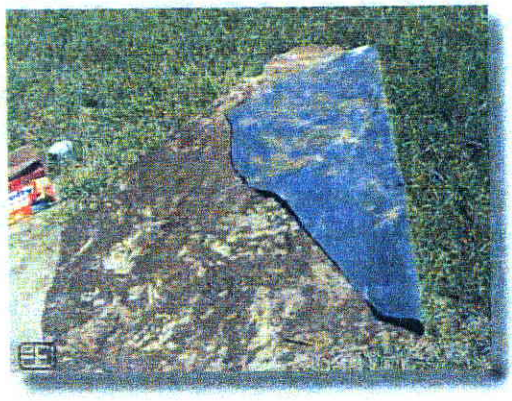
- From side slopes above water line
- From side slopes below water line under the cattails
- From the bottom of the ponds



Two samples were tested from each of these locations on 09/14/2000.

All samples removed from the pond felt very soft and flexible during the removal process. Material removed from the bottom of the pond was softer to the hand than the material from above the water line. Once samples were dried off, the samples felt

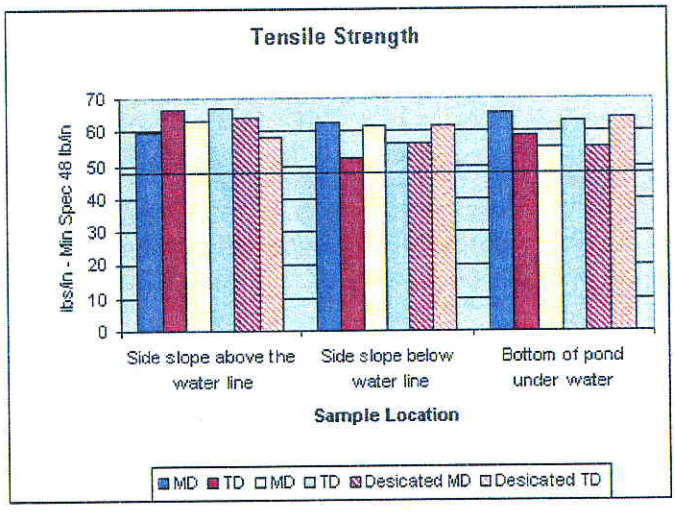
somewhat less flexible.



All samples were tested at the EPI Quality Control lab in the days following removal from the ponds. Materials were transported in large plastic bags, sealed to minimize moisture loss prior to testing.

Two samples were tested from each location without any preparation, other than removal of any sand or dirt from the material. Two additional samples from each location were cleaned and allowed to acclimate in the lab for 40 hours according to standard ASTM test methods. These samples are noted as desiccated and are the right most samples on the following graphs.

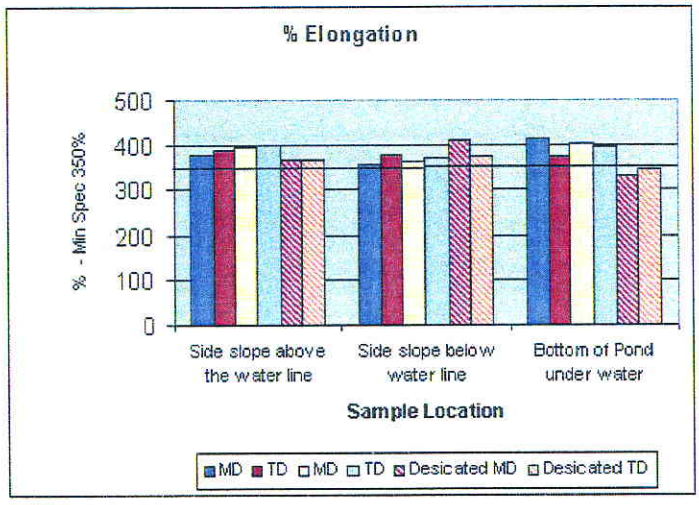
- Click for Slideshow One



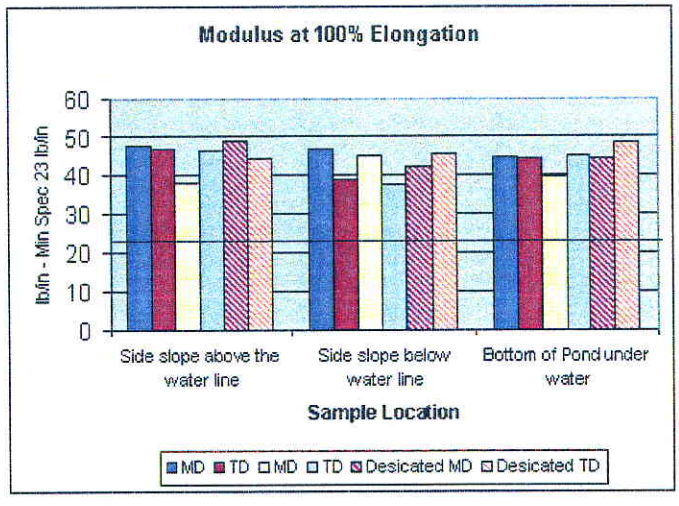
Samples from each location were tested in both the Machine (MD) and Transverse (TD) direction. The tensile strength for the 30 year old 20 mil PVC liner exceeded today's minimum specification for all of the samples tested.

- Click for Slideshow Two

It was noted during sample removal that the newly exposed material felt like new liner that would be installed in today's projects. It was also noted, that in a very short time the material began to loose a little of its flexibility as the material dried out. This is evidenced in the results of ultimate elongation tests run on the 18 different samples. The material that was acclimated in the lab and allowed to dry out, exhibited lower ultimate elongation in two cases, than those samples that were tested without acclimation.



Samples were also tested for modulus of elasticity, which is a measure of tensile strength at 100% elongation. This test will indicate how strong the material is when it is under stress. A low modulus indicates a softer, more elastic material, while a high modulus number indicates a stronger, stiffer material. PVC must exceed a minimum number, which will indicate use of proper plasticizer and other ingredients to make the product flexible, but tear resistant.



After 30 years of service, this 20 mil PVC geomembrane has retained its plasticizer and its flexibility, enabling it to perform its function without fail. It has also retained its strength and has not deteriorated, enduring thirty years in a buried environment. It has also resisted puncture by roots, biological attack from microorganisms, and has had no detrimental effect on the environment that it has protected since 1971.

The potential for root penetration was a big question in the forensic study of these ponds. Each of the ponds had a large amount of cattails around the perimeter of the pond.

As the bulldozer removed the dirt from the top of the liner under the cattail area, careful observation was made of the root zone of the cattails. These cattails produced one root stalk about 3/4" to 1-1/4" in diameter, with

a mass of smaller roots around the main root. The root length was approximately 1 to 3 feet. All roots of the cattails grew down to the liner, then grew horizontally along the top surface of the liner. No evidence of liner intrusion was found.

One of the ponds that samples were removed from had a small willow tree (12 – 15 feet tall) growing below the anchor trench but above the water level. The willow tree was located approximately 5 feet down the slope from the anchor trench and had a trunk of 6-8 inches diameter.

As the bulldozer operator cleared the dirt from the sides of the tree, it was observed that the tree roots grew similarly to the cattail roots. They grew down to the liner, then turned and traveled along the surface of the liner. Main roots were 3-5 feet long, with some smaller roots up to 7 feet from the trunk. When the dozer pushed the tree, it slid down the liner to the bottom of the pond, leaving the liner intact. No damage was found from roots penetrating the liner.

In the center of each pond was an inlet/outlet structure. This concrete slab was approximately 2.5 x 2.5 feet, with the top level with the liner sub grade. The liner was placed over the concrete, sealed with mastic, and fastened to the concrete using 2"x4" redwood batten strips and concrete nails. This structure and the batten

appeared to perform well over the thirty years as indicated by no discoloration of the soil color under the liner and around the structure.

For more information on this project, visit the Michigan State University web site for the W.K. Kellogg Biological Station at http://www.kbs.msu.edu/ . You can find additional information on the research ponds at PONDS and additional information and KBS News .

Thirty-Year Durability of a 20-Mil PVC Geomembrane

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In 1971, twenty circular aquaculture ponds were constructed for the W. K. Kellogg Biological Research Station in Hickory Corners, Michigan. The 30.5-m-diameter research ponds were lined using a 0.51-mm-thick fish-grade PVC geomembrane. Over the years the ponds became congested with dense, persistent stands of cattails, trees, and other vegetation, which required the ponds to be cleared and relined in September 2000 in order to allow the initiation of new experiments. The lack of holes in the exhumed geomembrane suggests that it resisted biological attack from microorganisms and also root penetration. Laboratory testing shows that the tensile behavior of the nearly 30-year-old PVC geomembrane is within current specifications for new 0.51-mm-thick PVC geomembranes. Test results also indicate that performing laboratory tests at *in-situ* moisture conditions provides a better estimate of the field properties of PVC geomembranes than desiccating the material prior to testing, as is required by ASTM Standard Test Methods. J. Vinyl Addit. Technol. 10:168–173, 2004.

INTRODUCTION

In 1971, twenty circular aquaculture ponds were constructed for the W. K. Kellogg Biological Research Station at the Michigan State University Facility in Hickory Corners, Michigan, under a grant from the National Science Foundation. Eighteen of the ponds were for experimental purposes and two were for water-storage purposes. The ponds were allowed to colonize naturally with flora and fauna from surrounding lakes, and within a few years the experimental ponds closely resembled natural systems. These conditions provided the opportunity to conduct a number of significant experiments on species interaction and habitat selection in fishes.

The 30.5-m-diameter research ponds were lined using a 0.51-mm-thick fish-grade PVC geomembrane. A fish-grade PVC geomembrane is specially formulated to promote aquatic life by not including biocides used in typical PVC geomembrane formulations. The biocides are excluded because they may leach out over time and injure the fish. The basic formulation of a PVC geomembrane corresponds to 60%–65% PVC resin; 32%–38% plasticizer; 5%–8% stabilizers, additives, and biocides; and 0.5%–1% pigment (1). The ponds are 8 feet deep with side slopes of three horizontal to one vertical. After installation, each PVC geomembrane was covered with 1 foot (0.30 m) of sandy soil cover.

Over time the ponds became congested with dense, persistent stands of cattails, trees, and other vegetation. These conditions made many types of experiments impossible, and thus, to start new aquaculture experiments, nine of the ponds were cleared and relined in September 2000. It is important to note that none of the ponds was leaking or exhibiting any problems during the nearly 30 years of service. However, the initiation of new experiments provided a unique opportunity to exhume approximately 30-year-old (29 years and 8

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months) PVC geomembranes and evaluate their engineering properties. Previous researchers have examined PVC geomembranes ranging in age from 2 to 30 years used both as canal liners in the western U. S. (2, 3) and as part of landfill cover systems in Florida (4, 5) and discovered that the geomembranes performed well. This case history is unique because it involves a 0.51-mm-thick PVC geomembrane in an aquaculture environment after nearly 30 years.

On September 13, 2000, Erik Newman of the University of Illinois at Urbana-Champaign (UIUC) removed samples of the geomembrane from the ponds. The samples were exhumed from three locations: 1) the side slopes above the waterline, 2) the side slopes below the waterline and under the cattails, and 3) the bottom of the ponds. The samples were sealed in large plastic bags to minimize moisture loss prior to testing at the UIUC. Some of the samples were shipped to TRI/Environmental in Austin, Texas, for comparison testing.

OBSERVATIONS OF GEOMEMBRANE DURING EXCAVATION

All the samples removed from the pond were soft and flexible, which is evident from their elongation-at-break values, presented subsequently, which still satisfy current specification values. The flexibility of the nearly 30-year-old material also is illustrated in *Fig. 1* by photographs of a tensile specimen from the side-slope material from below the waterline before and during tensile testing. It can be seen that the specimen is undergoing substantial elongation during testing without rupture. Material removed from the bottom of the pond was even softer and more flexible than the material from above the waterline, probably because of less desiccation occurring below the waterline. Once the samples were desiccated in accordance with ASTM test procedures, the samples were somewhat less flexible, which strongly suggests that exhumed material should be tested using *in-situ* conditions, i.e., without desiccation as required by ASTM Standard Test Methods, to properly assess the *in-situ* engineering properties. Desiccated specimens can be used for new material, but it is not recommended for exhumed material because the geomembrane has already become acclimated to field conditions.

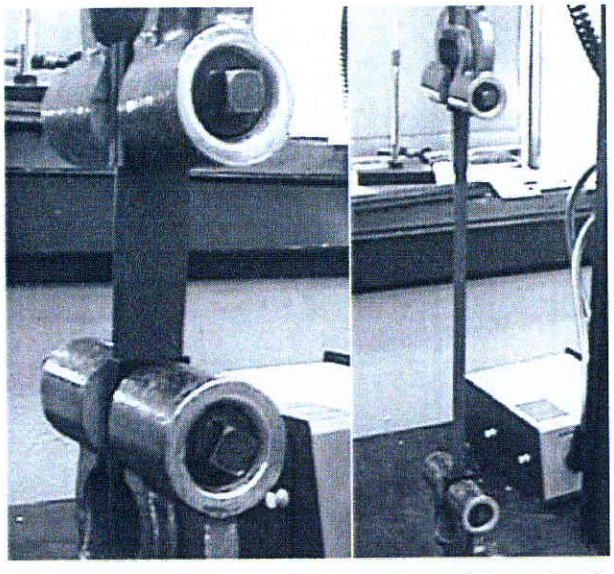

Fig. 1. Exhumed PVC geomembrane before and during tensile testing.

At the center of each pond an inlet/outlet structure was constructed. This structure consisted of a concrete slab, approximately 0.75 m × 0.75 m, with the top level with the liner subgrade. The liner was placed over the concrete, sealed with butyl mastic, and fastened to the concrete using 38 mm × 95 mm redwood batten strips and concrete nails. This structure and the batten performed well over the nearly 30 years, as indicated by no discoloration of the soil under the PVC geomembrane around the structure. These observations also indicate that there was little, if any, leakage through the liner in the vicinity of the inlet/outlet structure. The mastic was soft and flexible after nearly 30 years, which resulted in an effective seal around the nails used to fasten down the strips.

One of the main objectives of this study was to determine the effect, if any, of root penetration and microorganisms on 0.51-mm PVC geomembranes. The ponds were overgrown with vegetation and had a large number of cattails growing around the perimeter and in the middle of the ponds. As the bulldozer removed soil from the top of the geomembrane under the cattail area, observations were made of the root zone of the cattails. These cattails produced one root stalk about 20 to 30 mm in diameter, with a mass of smaller roots around the main root. The root length was approximately 0.3 m to 1 m. All roots of the cattails grew down to the geomembrane and then grew horizontally along the top surface of the geomembrane. No evidence of roots penetrating the 0.51-mm-thick geomembranes was found during field inspection or after holding the exhumed geomembrane over a light source in the laboratory.

In one of the ponds, a small willow tree was growing about 5 feet down-slope of the anchor trench but above the water level. The willow was approximately 4 m tall; its trunk was 150 to 200 mm in diameter. As the bulldozer operator cleared the soil from the sides of the tree, it was observed that the large tree roots also grew down to the geomembrane, then turned and traveled along the surface of the geomembrane. The main tree roots were 1 to 1.5 m long, with some smaller roots extending up to 2 m from the tree trunk. When the dozer pushed the tree over, it slid down the geomembrane to the bottom of the pond, leaving the geomembrane intact. Again no evidence of root penetration was found during field inspection and after holding the exhumed geomembrane from the vicinity of the willow tree over a light source. These observations are especially significant because the geomembrane is only 0.51 mm thick. The reasons the cattails and tree roots did not penetrate the

geomembrane include the resistance of the geomembrane to penetration and the fact that the roots grew laterally to remain in the soil. In either case, the adverse anecdotes that PVC geomembranes are penetrated by roots are not supported by this case history.

The lack of observed holes in the geomembrane also suggests that it resisted biological attack from microorganisms. There was no surficial damage to the geomembrane to indicate microorganism attack. This is particularly significant because the experiments introduced many types of microorganisms to the ponds. This qualitative data suggests that there has been no detrimental effect on the geomembrane from root penetration or microorganisms in this harsh and demanding environment since 1971. This case history also rebuts the adverse anecdotes that holes are eaten in PVC geomembranes by microorganisms.

TESTS ON EXHUMED GEOMEMBRANE

Experimental Procedure

Samples of the PVC geomembrane exhumed from above and below the waterline were tested at the UIUC to evaluate the effect of submergence on the engineering properties of the exhumed geomembrane. Only samples exhumed from below the waterline were tested at TRI/Environmental. Samples from each location were tested in both the machine (MD) and transverse (TD) directions. The test results were compared to the National Sanitation Foundation Specification (6), NSF-54, to quantify the changes in material and seam properties of the PVC geomembranes over the 29 years and 8 months of service. The NSF-54 specification was the applicable standard in 1971 when the ponds were constructed and was used for comparison purposes because pieces of the original material were unavailable for testing. To fill the void left by the obsolescence of NSF-54, which was last updated in 1993, the PVC Geomembrane Institute (PGI) developed and has periodically updated a specification for PVC geomembranes. Thus, to further evaluate the performance of the exhumed geomembrane, the corresponding values of the latest PGI specification, PGI-1103 (7), are also shown for each test. The PGI-1103 specification became effective January 1, 2003.

Some of the samples from each location were cleaned and allowed to acclimate and desiccate in the laboratory for 40 hr according to the applicable ASTM standard test methods. Other samples from each location were tested without allowing desiccation in the lab by storing the material in a moist room until testing. This non-desiccation procedure was implemented to provide a better estimate of the *in-situ* properties as the geomembrane was kept at a high moisture content. It is believed that the non-desiccated material provides a better simulation of the field moisture conditions. The desiccated test results presented herein present a worst-case scenario for the engineering properties of the *in-situ* material because the material has been desiccated. The applicable ASTM testing specifications are listed in *Table 1*.

Results and Discussion

The test results shown in *Table 2* are for material obtained from near the bottom of one of the ponds and desiccated prior to testing. *Table 2* shows agreement between the test results obtained from the UIUC and TRI/Environmental (TRI). More important, the results show that the properties of the nearly 30-year-old material exceed the NSF-54 required values and the more restrictive PGI-1103 values. For example, the tensile property data shows a sufficient percent elongation at break (greater than 360%) in both the MD and TD directions, which indicates that the material retained its flexibility. It can also be seen that the TRI/Environmental values of elongation at break are a little higher than the UIUC values but in agreement, and both exceed the NSF-54 and PGI-1103 values. Samples were also tested to determine the secant modulus of elasticity, a measure of geomembrane flexibility even after nearly 30 years in an aquaculture environment, which is calculated using the load required to achieve 100% axial

Table 1. Summary of Tests and Specifications.

Test Description	ASTM Specification (11)	NSF-54	PGI-1103
Break strength (kN/m)	D 882, Method A	8.1	8.4
Elongation at break (%)	D 882 (A)	325	360
Secant modulus at 100% strain (kN/m)	D 882 (A)	3.5	3.7
Tear resistance (N)	D 1004	26.7	27.0
Bonded seam shear strength (kN/m)	D 882	6.4	6.7
Hydrostatic resistance (kPa)	D 751 (A)	413	470
Thickness (mm)	D 5199, D 1593	0.48	0.49
Dimensional stability (% change)	D 1790 (100°C, 0.25 hr)	± 5	± 4
Water extraction (% change)	D 3080	−0.25	−0.15
Volatile loss (% loss)	D 1203	0.90	0.90
Low temperature brittleness (% passing)	D 1790	80	80

strain in the tensile test. A low secant modulus indicates a softer, more elastic/flexible material, while a high modulus indicates a stiffer material. The secant modulus is approximately two times higher than the specified value, which indicates that some hardening occurred over the 30 years of service. The hardening also may have contributed to the result that the tensile break strength values comfortably exceeded both specifications. In summary, the engineering properties of the nearly 30-year-old submerged material exceed both the NSF-54 and the PGI-1103 specifications even though the material was desiccated prior to testing.

The results of the water extraction and volatile loss tests also confirm sufficient plasticizer retention after nearly 30 years. One interesting result is the water extraction data. The UIUC data indicates a gain in water during the test, as did the TRI/Environmental data, albeit to a lesser degree. This may be attributed to desiccation of the material prior to testing and the material gaining water during the test to return near the field condition. This behavior reinforces the recommendation that exhumed specimens should be tested at *in-situ* moisture conditions and not after desiccation.

The factory geomembrane seams were created using a solvent, and the performance of the seams over approximately 30 years was of particular interest. It can be seen from *Table 2* that the bonded shear strength exceeds the recommended NSF-54 and PGI-1103 values. Peel tests of the seams were not conducted because the factory solvent seams did not have a "flap" to permit peel testing. TRI/Environmental did not test a seam because the material that was shipped did not contain a seam. In summary, factory solvent seams appear to be extremely durable, which is important because PVC geomembranes in projects of this size can be fabricated entirely in the factory, folded, and shipped to the site for installation. This allows every seam to be made under controlled factory conditions. On large projects, some field seaming may be required, and research is being conducted to investigate the behavior of field PVC seams (8, 9), but factory seams appear to be satisfactory.

Plasticizer retention is more difficult in an aquatic environment than a non-aquatic environment because as the water or liquid continuously circulates, it provides a continuous opportunity for plasticizer to migrate into the liquid (10). In addition, the thinner the PVC geomembrane, the larger the impact of surficial plasticizer loss on the engineering properties will be. For example, the percentage change in engineering properties can be greater for a 0.51-mm versus a 0.76-mm-thick PVC geomembrane. Therefore, the test results on a 0.51-mm-thick PVC geomembrane after nearly 30 years in an aquatic environment still exceeding the NSF-54 and PGI-1103 recommended values is significant in confirming plasticizer retention with time. This also indicates that the formulation was proper and the plasticizer was sufficiently retained even in a harsh aquatic environment.

Material from above the waterline was also desiccated prior to testing in accordance with ASTM Standard Test Methods, and the results are shown in *Table 3*. It is expected that plasticizer retention above the waterline will be higher than that below the waterline, as water is not continuously present to remove some of the plasticizer. Evidence of greater plasticizer retention can be seen in comparing the tensile properties in *Tables 2* and *3*. For example, the break strength is lower for the material above the waterline, indicating a slightly softer material than below the waterline. This additional plasticizer retention above the waterline is also reflected in the larger value of percent elongation at break (369% versus 362%) and a lower value of secant modulus (8.4 kN/m versus 9.8 kN/m) in the machine direction than the below-waterline material. This suggests that the material is more flexible above the waterline probably because of greater plasticizer retention. As in *Table 2*, the water extraction data shows a

Table 2. Desiccated, Machine Direction/Transverse Direction Properties for Desiccated Material Exhumed From Below the Water Level.

Test	UIUC	TRI
Break strength (kN/m)	12.6/10.3	10.9/10.5
Elongation at break (%)	362/361	368/447
Secant modulus at 100% strain (kN/m)	9.8/8.9	*
Tear resistance (N)	59.2/53.8	37.4/36.4
Bonded seam shear strength (kN/m)	9.1	*
Hydrostatic resistance (kPa)	1029	710
Thickness (mm)	0.48	0.52
Dimensional stability (% change)	−4.0/−1.4	−2.0/0.9
Water extraction (% change)	0.09	0.04
Volatile loss (% loss)	0.01	0.26
Low temperature brittleness (% passing)	83	100

*Not tested

Table 3. Machine Direction/Transverse Direction Properties for Desiccated Material Exhumed From Above the Water Level.

Test	UIUC
Break strength (kN/m)	10.5/10.0
Elongation at break (%)	369/361
Secant modulus at 100% strain (kN/m)	8.4/8.2
Tear resistance (N)	50.2/47.1
Bonded seam shear strength (kN/m)	8.6
Hydrostatic resistance (kPa)	1034
Thickness (mm)	0.48
Dimensional stability (% change)	−4.0/−4.0
Water extraction (% change)	0.10
Volatile loss (% loss)	0.10
Low temperature brittleness (% passing)	83

gain in water during the test, which may be caused by desiccation prior to testing. In summary, the data in *Table 3* shows there is greater plasticizer retention in a non-aquatic environment, which results in a greater retention of flexibility even after nearly 30 years. This suggests that a PVC geomembrane in a non-aquatic environment, such as a landfill cover system, should experience excellent plasticizer retention and at a minimum better retention and performance than the below-water-level material, which exhibited good performance for nearly 30 years.

In addition to testing the desiccated material according to the applicable ASTM standards, specimens were maintained and tested at their *in-situ* water content. These results are summarized in *Tables 4* and *5* for samples obtained below and above the water level, respectively. The secant modulus of the *in-situ* moisture content specimens is smaller than that of the desiccated material. This indicates that the PVC is more flexible at field moisture conditions than after it is desiccated. The elongation at break is also correspondingly larger for the non-desiccated material because it is more flexible than the desiccated material.

The *in-situ* results for the volatile loss and water extraction tests may be inaccurate because the ASTM procedure involves weighing samples before and after the tests and the specification was intended to be used for desiccated material. Therefore, the specification values are based on desiccated weights of the material and may not be meaningful for material that was tested at the field water content. It is proposed herein that testing exhumed geomembrane at the *in-situ* conditions provides a better representation of the field behavior than desiccating the samples. Therefore, ASTM D3080 and D1203 should be modified to allow testing of exhumed geomembranes at field conditions.

Table 4. Machine Direction/Transverse Direction Properties for Non-Desiccated Material Exhumed From Below the Water Level.

Test	UIUC
Break strength (kN/m)	12.4/11.6
Elongation at break (%)	384/386
Secant modulus at 100% strain (kN/m)	9.4/9.1
Tear resistance (N)	57.8/50.3
Bonded seam shear strength (kN/m)	9.3
Hydrostatic resistance (kPa)	941
Thickness (mm)	.48
Dimensional stability (% change)	−2.5/−0.7
Water extraction (% change)	0.40
Volatile loss (% loss)	−1.13
Low temperature brittleness (% passing)	83

Table 5. Machine Direction/Transverse Direction Properties for Non-Desiccated Material Exhumed From Above the Water Level.

Test	UIUC
Break strength (kN/m)	11.8/10.3
Elongation at break (%)	394/412
Secant modulus at 100% strain (kN/m)	8.4/7.9
Tear resistance (N)	49.8/46.7
Bonded seam shear strength (kN/m)	8.6
Hydrostatic resistance (kPa)	903
Thickness (mm)	0.48
Dimensional stability (% change)	−4.0/−3.9
Water extraction (% change)	0.41
Volatile loss (% loss)	−0.11
Low temperature brittleness (% passing)	83

CONCLUSION

After nearly thirty years of service in an aquatic environment, a 0.51-mm-thick PVC geomembrane retained its flexibility and strength, enabling it to perform as a successful water barrier. This indicates that plasticizer retention in an aquatic environment is not a problem even with 0.51-mm-thick material. These results are significant because they not only support the use of PVC geomembranes in aquatic applications, but also support their use in non-aquatic applications, because a non-aquatic environment is less problematic in terms of plasticizer retention than an aquatic environment. This is reinforced by comparison of the test results for material from above and below the waterline, which shows plasticizer retention is greater for the above-waterline material in *Tables 4* and *5*. This case history also shows that PVC geomembrane material and its seams are not compromised or deteriorated by root penetration or microorganisms after nearly 30 years, even though the material is only 0.51 mm thick.

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Appendix C

2012 - 2013
USA WATER SKI

TOWBOAT POLICY MANUAL
Policies and Guidelines
For the 2012-2013 Towboat Year

Member of the
UNITED STATES OLYMPIC COMMITTEE

STATEMENT OF PURPOSE REGARDING THE TESTING OF TOWBOATS

The American Water Ski Association (AWSA) is the three-event sport discipline of USA Water Ski (USA-WS). AWSA's National AWSA Towboat Committee is charged with the qualifying of boats for use in three-event water ski competition (slalom, tricks, and jump). The scope of boat testing and the future direction of all associated activities shall be guided by the following directives:

PERFORMANCE STANDARD

Boats to be used in competition must meet certain performance standards, which have been established by the AWSA Towboat Committee. Performance standards for tournament use shall be those, which allow skiers, drivers, and officials to perform up to their maximum ability in water ski situations. The committee shall review these standards annually, and change or add to them as deemed necessary. If the change impacts recognized international standards, the change will be made in coordination and cooperation with the International Water Ski Federation.

BOAT SELECTION

Through an annually administered program of boat testing, the committee (and appropriate sport division AWSA Towboat Committees) shall determine which boats meet the established performance standards and criteria and shall certify those boats as approved for use in tournaments sanctioned by USA Water Ski.

TOWBOAT PROGRAM

The committee shall use established standards and approvals as a basis for the program through which boats qualify to participate in Regional and National Championships. Any boat which passes the Towboat Evaluations, shows commitment to tournament use, and demonstrates skier acceptance may achieve participation at the National level, thereby promoting a measure of open competition in the tournament boat market, as deemed desirable in the original committee mandate.

TEST RESULTS

During the testing process a considerable amount of information is developed and compiled for committee use. While the tests are held for the purpose of determining boat performance, it is desirable that, as much as possible, the boat manufacturers benefit from the testing information as well. It shall be a goal of the tests to make data and comments on each boat available to that manufacturer for his own use. In all other respects, test data are confidential and may not be used by manufacturers for promotional purposes.

RESEARCH AND DEVELOPMENT

The testing program shall support and promote the advancement of water skiing by investigating, encouraging and testing innovations in boat design and related equipment. USA-WS seeks to cooperate with manufacturers by offering the testing process as a research tool whenever possible.

TESTING TECHNOLOGY

In order for the USA-WS boat tests to remain successful and produce useful and accurate information, which is verifiable, a continuing process of systems upgrading is necessary. Incorporating applicable improvements in technology is seen as an investment in the future of the tests, and will help ensure USA-WS' position of leadership in setting standards for ski boat performance. The technical controller of the tests shall inform USA-WS of equipment needs, and funding for new technology shall be an annual item within the towboat program budget.

TEST FEES

USA-WS volunteers have invested a great deal of time and expertise in establishing and maintaining the professional quality of the tests. This significant pool of labor and technology has made it possible for USA-WS to carry on a well-run testing program while allowing the organization to benefit financially. It has also enabled USA-WS to keep the testing fees at a much lower level than would be possible if these services were purchased from an outside source. While the current situation is beneficial to both USA-WS and the manufacturers, changes in circumstances in the future could necessitate changes in policy regarding test personnel and test fees. The boat test budget and fees shall be determined by the USA-WS Executive Committee. A manufacturer can test multiple speed control systems on a specific towboat model with test fees to be determined by the USA-WS Executive Committee.

TEST INTEGRITY

In conducting the boat tests, the committee is charged with safeguarding the integrity, quality, and independence of the tests as they serve to assure the quality and performance of boats for tournament use. The committee members and all test personnel shall strive to be unbiased as well as uncompromising in applying the standards set, and in all aspects of decision making.

SPORT DIVISIONS

The AWSA Towboat Committee will assist other Sport Divisions in establishing on-site operational procedures for testing of boats. The AWSA Towboat Committee will make the test site and equipment available to other Sport Divisions. Sport Division test criteria and evaluation procedures will be developed in cooperation with the AWSA Towboat Committee.

TOWBOAT TEST SYNOPSIS - 3 Event Boats

The USA Water Ski towboat evaluations are intended to qualify towboats for use in sanctioned USA Water Ski competitions and sponsored programs. The technical aspects of the evaluations are designed to measure and test a towboat's performance under simulated tournament conditions. Each test has specific performance criteria, and all towboats must meet or exceed these pre-determined performance standards.

1. POWER AND ACCELERATION

The object of these tests is to determine whether a boat has adequate power to pull slalom and jump events. The distance required to pull a skier from a deep-water start on a competition slalom ski and accelerate to 36 mph will be measured. This distance may not exceed 250 feet, and must not exceed 230 feet to pull Record Capability tournaments. The distance required to pull a skier from 35.4mph to 38.2mph will also be measured and must not exceed 70 feet to pull Record Capability tournaments. Alternatively, a load device, capable of consistently simulating the resistance of a skier throughout the designated course may be used to replace the skier. If a boat passes the power & acceleration test portion, its power will be further tested during the slalom and jump deviation tests. Failure to meet these marks indicates lack of appropriate power. All drivers will observe the adequacy of power while pulling skiers under tournament conditions. This testing includes the ability to consistently obtain times within the allowed tolerances for slalom and jump courses.

2. SLALOM COURSE CENTERLINE DEVIATION

The amount of boat path deviation, which will be influenced by the pull of a slalom skier, will be measured. Two factors will be measured: average deviation and maximum deviation from the boat's path. Measurements will be made with a skier skiing at speeds of 34.2mph (55kph) and 36mph (58kph) at 18.25m. 16m, 14.25m, 13m, 12m, and alternatively 11.25m line lengths. The average deviation must be less than .4 feet (.12m), and the maximum deviation will also be measured.

3. JUMP COURSE CENTERLINE DEVIATION

The amount of boat path deviation, which will be influenced by the pull of a jump skier, will be measured. Two factors will be measured: average deviation and maximum deviation from the boat's path. Measurements will be made with the skier skiing at maximum division speed and actually jumping over the ramp or skiing through a set of buoys that simulate a jump ramp. The average deviation must be less than .8 feet (.24m) and, the maximum deviation will also be measured.

4. SLALOM SPRAY

While running the slalom course, boat spray should not significantly affect the skier's performance. Since this test is subjective, comments from the test skiers, all experienced competitors, will be recorded for the manufacturer's information. If all testing skiers independently agree that the spray has significant negative effect, the committee will review the data and may disqualify the boat.

5. SLALOM WAKE

The slalom wake and rooster tail should not significantly affect the skier's performance. Since this test is subjective, comments from the test skiers, all experienced competitors, will be recorded for the manufacturer's information. If all testing skiers independently agree that the wake has significant negative effect, the committee will review the data and may disqualify the boat.

6. TRICK WAKE

The trick wake and table should not have significant negative effect on the skier's performance. Since this test is subjective, comments from the skiers, all experienced competitors, will be recorded for the manufacturer's information. If all testing skiers independently agree that the wake and table have significant negative effect, the committee will review the data and may disqualify the boat.

7. JUMP WAKE

The jump wake and pull should not have significant negative effect on the skier's performance. Since this test is subjective, comments from the skiers, all experienced competitors, will be recorded for the manufacturer's information. If all testing skiers independently agree that the wake and pull have significant negative effect, the committee will review the data and may disqualify the boat.

8. DRIVABILITY

While pulling slalom, jump and tricks, the boat's combination of power package, design characteristics, speed control, and instrumentation should not negatively affect a driver's ability to give smooth, consistent pulls within required record capability tolerances. Comments and evaluations from the test drivers will be recorded. The committee will review the data, and should significant problems be agreed upon, the boat may be disqualified.

9. HANDLING AND MANEUVERABILITY

Each boat will be required to make a series of turns forming a "figure eight" pattern with circle diameters of 75 feet. Two passes will be made, one at 17 mph and one at 26 mph, both within the same described pattern. The boat will then be required to make a 180 degree turn at 36 mph within the 150 ft. diameter course. This pattern will be repeated in the opposite direction at 36 mph. Each boat's performance will be monitored to ensure that all maneuvers are made safely and under control. All turns, both left and right, must be completed successfully to pass this test. See test forms for course diagram.

10. ENGINEERING

The object of this test is to determine whether a boat's design will in any way hinder the performance of officials or skiers, or whether it presents any obvious safety hazards. The boat will be examined and analyzed from a tournament driver's perspective in areas such as human engineering and practicality for tournament usage. Comments from the drivers will be recorded for the manufacturer's use and information. Serious deficiencies will be noted and if, after presentation of the findings to the manufacturer the problem cannot be corrected, the boat may be disqualified.

11. SOUND LEVEL TESTING

For the purpose of knowing that boats passing USA Water Ski's tests are not in violation of generally accepted maximum noise level standards, the noise produced by boats during typical tournament situations will be measured. Specifically, measurements will be taken from shore with a sound level meter during slalom deviation passes. Neither the average sound level for 36 mph passes nor the average sound level for 34.2 mph passes may exceed 75 dB(A). Failure to meet this standard constitutes a disqualification for the boat. Testing is done from shore as follows:

a) Place dB meter at a point 125 feet from centerline of the slalom course
b) Align dB Meter with buoy #2 or #3 on the opposite side of the course from the buoy. That way the skier is farthest from the sound meter in order to minimize noise from the ski and skier.

12. ENGINE STANDARDIZATION (by protest only)

Bore, stroke, compression, camshaft specifications and other features of the engine in each test boat will be subject to analysis by an independent source that will be on site at the evaluations. Data collected will be compared to the homologation specifications provided in advance by the engine manufacturer.

ON-WATER TESTING

1. During Power and Acceleration, Slalom Centerline Deviation, and Jump Centerline Deviation tests, two representatives of the boat being tested will be allowed to observe the testing of their products only.

2. At the conclusion of Power and Acceleration, Slalom Deviation and Jump Deviation testing, results will be communicated to the manufacturer's representatives, if available. Other test results will not be available until after final analysis.

3. For the Power and Acceleration test, each model will be allowed three attempts. If the boat fails, the manufacturer or his representative on the test site will be notified of the failure. The AWSA Towboat Committee Chairman will determine the specific time period allowed during which to make changes to the boat.

   During the allotted time period, the manufacturer may make any changes he desires, the nature of which must be clarified to the AWSA Towboat Committee Chairman. The AWSA Towboat Committee Chairman is to be notified when modifications have been completed.

   The boat will then be allowed three additional attempts to pass the test. If the boat does not pass, it will be disqualified. At his option, the manufacturer may elect to have the boat continue with the remaining tests for performance analysis only.

4. The propeller may be changed as an alteration to complete the Power and Acceleration test. The propeller with which the boat passes Power and Acceleration will be recorded, and must then be used for the remainder of the tests. Thereafter no propeller changes are allowed.

5. For the Sound Level Test, noise output will be measured and recorded during the Slalom Deviation testing. If the boat fails the test, the manufacturer or his representative will be notified of the failure. The AWSA Towboat Committee Chairman will determine the specific time period allowed during which to make changes to the boat.

   During the allotted time period, the manufacturer may make changes to the noise reduction system, the nature of which must be clarified to the AWSA Towboat Committee Chairman. The AWSA Towboat Committee Chairman is to be notified when modifications have been completed.

   The boat will then be retested by means of simulated slalom passes at the appropriate speeds. If noise levels again exceed the maximum allowable decibels, the boat will be disqualified. At his option, the manufacturer may elect to have the boat continue with the remaining tests for performance analysis only.

   Following modifications and successful completion of the sound level testing, the Committee reserves the right to require retesting of Power and Acceleration.

BOAT PREPARATION FOR TESTING

It is the Committee's desire that all boats perform well and pass the boat tests easily. Often this is not the case, due to a lack of proper preparation. Each manufacturer needs to be aware of all requirements in the Policy Manual. He should review the series of tests to be performed, and be certain that his boat can meet the minimum test requirements. The boat itself is not ready until it has been fine tuned, just as each promotional boat should be. Tournament drivers expect the following:

Engine: Engines perform better with 10 to 20 hours of running time. Break them in.

Throttle: Must be smooth - not stiff.

Shift: Must not be stiff.

Steering: Not stiff, needs slight torque. Should turn equally to the right and left.

Speed Control: Must be installed and calibrated correctly. The test team will not set up or change software.

RETESTING

Manufacturers may request the AWSA Towboat Committee evaluate a change to an already Approved USA-WS Towboat after the completion of the USA-WS Towboat Tests. The committee has the ability to determine the testing process and policies for the proposed change to be evaluated on a case by case basis. All costs incurred for retesting shall be paid by the manufacturer requesting the test. No changes will be evaluated or authorized between June 30 and the subsequent USA-WS Towboat Test.

CATASTROPHIC SITUATIONS

Should a manufacturer experience serious difficulties, which impact his ability to have a boat on hand and in test-ready condition at the required time, he shall present the facts to the AWSA Towboat Committee and USA Water Ski personnel. The Committee will consider the circumstances on a case-by-case basis and will work with the manufacturer to arrive at the most appropriate solution. Problems falling into this category are those such as catastrophe at the manufacturing plant immediately prior to the tests, and serious damage to the test boat occurring in transit, after arrival at the test site, or during the testing process.

FINAL ANALYSIS

1. Conditional Pass - When the Committee identifies a problem, which would cause a boat to fail, but which they feel could be easily and completely corrected by the manufacturer without testing verification, the boat will receive a "Conditional Pass". The manufacturer will be notified of the situation and the desired correction. If the manufacturer agrees to make the required changes, he will be given until December 1 of that year to submit photographs documenting the completed changes. Boats which do not comply will be removed from the approved list. If three or more of these problems exist in a particular boat, the Committee will review the facts and may disqualify the boat.

2. Condition Requiring Improvement - When the Committee identifies certain problems which they feel are serious enough to warrant change, but which involve redesign of some type, they may issue a warning stating the condition "MUST BE IMPROVED" the following year. If a boat has a "must improve" condition, the "USA-WS Approved" status for that boat is valid for only one year.

3. Performance of Promotional Boats - Throughout the year the Committee reviews field reports detailing boat performances in sanctioned tournaments. It is acknowledged that most manufacturers experience some problems with individual promotional boats from time to time. The Committee will, however, note repeated difficulties, which form a pattern, indicating a design problem with a particular model. These findings will be taken into consideration along with data from the actual test boat. Repeated field problems from year to year will be considered as an indication that promotional boats do not meet the established standards. Such a determination could be cause for failure.

4. Boats Supplied As Tested - Boats supplied in the field for use in USA Water Ski Class C and above sanctioned events are to be identical to the boat supplied for the tests. The engine, gear ratio, and propeller of the test boat are recorded and published, and may not be altered. Photographs and hull measurements are also taken for the purpose of verification, and should design changes be made after the boat tests, the boat will be removed from the approved list.

APPROVED TOURNAMENT TOWBOAT

- A boat model which passes the USA-WS Towboat Tests will be formally recognized and promoted by USA Water Ski as a USA Water Ski Approved Tournament Towboat. The use of "USA-WS Approved Towboat" and "AWSA Approved Towboat" shall be interchangeable. The manufacturer may use this designation to advertise and market his boat to the public.

- A boat model that successfully passes the USA-WS Towboat Tests will be eligible to receive invitations to USA Water Ski sanctioned events. Participation in specific events will be at the option of the local organizing body.

- The Pan American Region and International Water Ski Federation will be notified of all boats that have met USA-WS' test standards for pulling Record Capability Tournaments.

REQUIREMENTS FOR TESTING

A boat manufacturer may apply to have boats tested by USA-WS to determine if they meet USA-WS standards for pulling skiers in USA Water Ski-sanctioned tournaments (traditional, disabled, barefoot, collegiate, and kneeboard) and USA Water Ski-sponsored programs (i.e. training camps and clinics).

The manufacturer must meet the following criteria in order to participate in the USA Water Ski tests:

1. Current USA Water Ski Gold Corporate Member ($1,000).

2. Current American Water Ski Educational Foundation Member. ($100)

3. Current Water Sports Industry Association Member.

4. Coast Guard - and/or NMMA-Certification for each boat tested

5. Pay the appropriate testing fee for each boat model to be tested - specific payment dates and requirements will be established by USA Water Ski.

6. Be able to confirm that all financial obligations to USA Water Ski have been met in full before the start of the tests - specific dates and requirements will be established by USA Water Ski. A boat will not appear on the USA-WS Approved Towboats list (or in magazine) unless all fees have been paid.

GUIDELINES, POLICIES AND DEFINITIONS

Approved Categories

For purposes of AWSA Rules and Towboat Policies & Guidelines, the term "USA-WS Approved Towboat" and "AWSA Approved Towboat" shall be interchangeable.

- **USA-WS Approved Tournament Towboat**

  An USA-WS Approved Tournament Towboat is defined as a specific model that has successfully passed the USA-WS Approved Tournament Towboat evaluations. All boats undergo a series of 11 tests and sub-tests which include power and acceleration and centerline deviation. Only boats meeting Power and Acceleration standards for Record Capability Tournaments will be allowed to pull class E, L and R Tournaments.

  1. Changed or new models are required to physically test annually.
  2. Unchanged models need physically test every three years.

  A specific model that has passed the Towboat Evaluation Tests and successfully tows the National Championship Tournament earns the right to be called a **National Tournament Towboat**.

- **USA-WS Approved Boat**

  An USA-WS Approved Boat is defined as a towboat capable of pulling slalom, trick and jump skiers on tournament type lakes, but it does not meet the more rigorous performance standards of a USA-WS Approved Tournament Towboat. It is not approved for use in a Class F or above tournaments.

  1. An unchanged model needs to physically test every three years
  2. A model is determined by the wetted hull surface.
     a. May be open or closed bow.
     b. May be equipped with any engine/transmission/propeller combination approved by the AWSA Towboat Committee. The AWSA Towboat Committee may approve other engine /transmission/propeller combinations without physically testing.
  3. The fee for testing shall be determined by the USA-WS Executive Committee.

New or Modified Towboat

A towboat model tested at the preceding year's towboat test will be considered "new or modified" when any of the following conditions are met:

1. Non Propulsion System Related Items

   (a) The towboat hull / plug has been changed or modified in any way from the gunnel downward. This includes changes to spray rails, strakes, etc. This also includes a change in the size or location of the stability fins or shaft location.

   (b) A change is made from a closed deck to an open bow, or vice versa.

   (c) There is a change in engine placement or location.

   (d) A change in speed control software or hardware that impacts the skiers' pull in slalom, trick or jump.

   (e) There is a change in total weight of more than 10%.

   (f) Any other changes must be approved by the AWSA Towboat Committee prior to the boat tests.

2. Propulsion System Related Items

   (a) There is a change in the engine manufacturer or model as tested from the previous year. This includes cubic inch displacement, horsepower, carburetion/EFI, engine management system (ECM), etc.

   (b) There is a change in transmission gearing (e.g., 1:1, 1.25:1, 1.5:1, etc.).

   (c) There is a change in propeller size, blade number or material (I.e.: bronze to stainless).

Towboat Changes

1. Throttle linkage changes: Modifications to the throttle linkage are allowed but must be a matter of owner responsibility and preference. If dual boats are used, performance must be equal.

2. External fixtures: Trim tabs, cavitation plates or other similar devices affixed to the hull that are adjustable must have a mechanism of verifying their position. Devices shall be used "as tested". Use of any setting "in between" is NOT permitted.

3. Bimini Tops: Bimini tops may be used during competition. Dual boats are not required to both have tops. If a bimini top physically affects the performance of the boat or the skier, no top will be used.

4. Wakeboard towers that do not affect the performance and handling characteristics of a towboat may remain attached to a USA-WS Approved

towboat during a USA-WS sanctioned event. The rope cannot be attached to the tower and the tower may not be used for towing skiers in an USA-WS 3-event tournament.

5. For minor changes in propulsion system components, a manufacturer may submit a request to the AWSA Towboat Committee that the change be considered "minor" and request that the boat be excluded from a physical retest in its second year of eligibility. Documentation of the proposed change and effect on the towboat performance shall be submitted to the committee. The AWSA Towboat Committee shall make its determination of testing based on the information provided by the manufacturer, performance of the current model in tournaments, and data from the prior year boat test. The decision shall be final and will be made on an individual boat basis. Examples of such changes might be a small horsepower change, EFI modifications, etc.

Towboat Model

Any boat is considered to be a different model if any of the three following conditions exist:

1. The model is advertised as a different model by a manufacturer. This will be the case even if all physical and technical characteristics are the same as another model.

2. Changes in Non Propulsion System Items as defined in the definition of "New or Modified Towboat".

3. If a manufacturer chooses to market the same boat as 2 different models, they may get USA-WS Approved status for both boats by testing one boat only. Same boat means physically and technically the same boat. The boats may have a different cosmetic scheme or model name but must otherwise be identical. Documentation (to include photographs and narrative description of any differences between the two boats) must be submitted to and approved by the AWSA Towboat Committee prior to the towboat tests. The additional fee for the second boat will be determined by the USA-WS Executive and Finance Committee.

A manufacturer may add special graphics, endorsements or signatures and the boat will be considered the same model if it is advertised under the same model name and/or model number and the physical and technical specifications are the same.

Towboats Supplied "As Tested"

No equipment or device will be attached to any towboat that affects performance, handling, maneuverability unless such equipment has been tested as part of the USA-WS Approved Tournament Towboat tests or such equipment is otherwise tested and/or approved by Technical Committee and/or the AWSA Towboat Committee. This includes speed control devices, wakeboard towers, and extended pylons. Trim tabs, cavitation plates or other similar devices affixed to the hull that are adjustable must have a

mechanism of verifying their position. Devices shall only be used "as tested". Use of any setting "in between" is NOT permitted.

Exceptions for tournament use with respect to this policy may be made with joint approval of both the Chairs of the Technical Committee and the AWSA Towboat Committee. Where such new equipment will be attached to a towboat, a tournament sponsor should request an exception as indicated above from the Chairs of the Technical and AWSA Towboat Committees. Such use shall be for data gathering purposes. Risk management, safety, maneuverability and technical issues are to be assessed to ensure that safe conditions are maintained and exercised.

For any tournament held at an elevation of 2000 feet or greater, or at a site with a short setup (less than 2000 feet), the tournament sponsor may request an exception to the "AS TESTED" policy, by submitting a formal request to the Chair of the AWSA Towboat Committee. The Chair may grant a change in "pitch" only (i.e. A change from a 14x18 to a 14x16 or from a 14x16 to a 14x14, etc.). The propeller must be the same manufacturer, same material, and same number of blades.

Unchanged Model

A specific boat model is unchanged or unmodified if that particular boat model does not meet the criteria for a "New or Modified" Towboat. An unchanged model need only be physically evaluated every three years, unless the model receives a "must improve", in which case, the model is only approved for one year.

Towboat Use: Model Year

a) AWSA Nationals, AWSA Regionals, and Record Capability (Class E,L,R) tournaments may use a current year 2013 USA-WS Approved boat or a prior year 2012 USA-WS Approved boat.

b) Class C, and F tournaments may use 2013, 2012, 2011, or 2010 Approved towboats (current and three years prior).

c) In all instances where a boat older than the current model year is used, the manufacturer must also have a boat on the approved list for 2013.

d) In cases where dual boats are required, both boats must be the same model and year.

Exceptions for Use – Approved Tournament Towboat

a) Exceptions for use of any other boat not on the "approved list" may be made by the Chair(s) of the AWSA Towboat Committee. The boat shall be considered an "Approved USA-WS Tournament Towboat" for that event.

b) Older Boats – If there are not sufficient numbers of approved boats available in an area for use, the LOC may apply to their Regional AWSA Towboat Committee member (or Chair(s) of the AWSA Towboat Committee) for use an OLDER model year towboat. Consideration will be given to the condition of the boat, speed control system and version of speed control software in the boat.

Towboat Credit

All eligible year Approved Towboats participating in USA-WS sanctioned tournaments will receive credit toward Regional and National Tournament participation. For 2013, this includes 2013, 2012, 2011 and 2010 boats.

a) Credits for quantitatively qualifying for Regionals and Nationals shall be by manufacturer, not by specific model. An individual manufacturer may use any of its USA-WS Approved Tournament Towboats toward accumulating credits.

b) For manufacturers that currently have a Record Tournament Capable USA-WS Selection of USA-WS approved boats to be used in specific tournaments will be at the option of the local organizing body.

c) Towboat not used: A towboat manufacturer will receive credit for towing a particular USA-WS sanctioned tournament if he can provide documented evidence that he was invited to provide towboats for the tournament in question, accepted, and that the towboats were made available in sufficient time and in acceptable condition for use in the tournament, but were not used.

d) Credit Period: Approved Towboat the towboat qualification earning period shall be July 1st through June 30th. For manufacturers that do not currently have a Record Tournament Capable USA-WS Approved Towboat, the credit earning period will begin at the conclusion of the USA-WS/AWSA Boat Test and conclude the following June 30. The 20% quantitative requirement for participation in AWSA Regional and National Tournaments for these new boats will be calculated from the number of tournaments during that period.

e) Manufacturers are encouraged to have their promotional team coordinators contact tournament sponsors to arrange for boat participation at tournaments. Sponsor information can be obtained from Regional Guide Tournament announcements. Manufacturers are also encouraged to develop a form for their promotional team member to verify towboat tournament participation. The form should be signed by the chief judge and chief driver at the tournament. The manufacturer will then have a backup system for verifying towboat participation.

f) Tournament cancellation: A USA-WS approved towboat manufacturer will receive credit for towing a particular USA-WS sanctioned tournament if he can provide documented evidence that he was invited to provide towboats for the tournament in question and accepted, but that the tournament in question was cancelled with insufficient time (less than four weeks) to make other arrangements for use of his boats at another USA-WS sanctioned tournament.

g) Closed Tournaments: If a sanctioned tournament is not open to all USA-WS Approved Tournament Towboats the tournament will NOT be included in the total number of tournaments used to determine the 20% quantitative requirement. Those boats participating in the closed tournament will NOT receive credit from that tournament toward qualifying quantitatively for Regionals and Nationals.

If a towboat manufacturer contacts a tournament sponsor and is told that the manufacturer's boat is not welcome or cannot be used at that particular site, the tournament will pulled from the list to determine the 20% eligibility requirement. No other boats used in that particular tournament will receive credit.

A tournament sanctioned as "open to all USA-WS Approved Towboats" that prohibits participation by a manufacturer shall be individually reviewed by USA-WS Headquarters and the AWSA Towboat Committee. Sanction forms for USA-WS sanctioned USA-WS events shall include a question asking if the tournament or clinic is open to all USA-WS Approved Tournament Towboats.

New Model Towboat Use Before Boat Tests

a) If a manufacturer qualifies and participates in the previous year's AWSA National Tournament he may use a new or modified untested model towboat in tournaments between the current year's AWSA Nationals and the subsequent USA-WS boat tests.

b) The new or modified untested boat must be the same model or the model intended to replace the manufacturer's current Nationals Towboat.

c) A new model year USA-WS Approved towboat which is unchanged may be used prior to the USA-WS Boat Tests provided an exception is requested of the Towboat Committee and subsequently granted. (Rationale – allows a promotional boat owner to sell a current year boat in early to mid- season and take delivery of an unchanged new model year boat and still meet tournament commitments.)

d) Subsequently if the boat receives USA-WS Approved status at the boat tests, it will receive credit toward qualifying for next year's Regionals and Nationals for those tournaments pulled between Nationals and the boat tests.

e) Any records set behind the boat prior to the boat tests would be pending until the boat receives USA-WS Approved status.

Towboats Used In Practice

Promotional towboats are not to be used other than to tow competitors at sanctioned tournaments; unless arrangements are made between towboat owners and sponsors. While a tournament sponsor may offer paid ski practice, it is not part of the USA-WS sanctioned tournament, and therefore the sponsor is responsible for supplying boats used in practice; unless arrangements have been made with a promotional boat owner to supply his boat for practice. Any arrangement for use in practice does not alter the number of boats the manufacturer must supply for the tournament should a boat be damaged accidentally during practice. Financial responsibility for damage occurring

during practice is determined by the agreement between the sponsor and the boat owner. Failure to pay when appropriate may result in loss of sanction.

Damage

A club (local organizing committee) is responsible for any damage to a towboat from the time it is delivered to the event site for use until it is returned to the promotional owner or his agent. In the event a towboat sustains damage at an event, a club (local organizing committee) is responsible for reimbursement to a promotional towboat owner of either his deductible or for repair costs up to a maximum of $500.00. Cleaning costs are not considered damage. Failure to pay damages, when appropriate, may result in loss of sanction for this and future tournaments.

At tournaments which the club (local organizing committee) does not select the drivers for their tournament (i.e. Team Trials, Regionals, Nationals), the financial responsibility for reimbursement of insurance deductible or repair costs shall be shared equally among the club (local organizing committee) and the organization responsible for selecting the drivers for the event.

Event

Event shall mean a slalom, trick or jump event. Multiple rounds are not to be counted as separate events. One credit per tournament may be earned regardless of number of rounds.

Online Tournament Kit

The tournament kit shall contain a separate section for the Chief Driver. The Chief Driver is responsible for returning towboat forms directly to headquarters. Towboat forms may be enclosed with the tournament report sent to HQ.

Towboat Use Documentation and Performance Report

An unacceptable performance at a tournament does not count as credit towards qualifying a boat for the Regional Championships. A boat shall receive credit for the events pulled unless its performance is deemed unacceptable for tournament use. Such factors are: boats exhibiting inadequate power to maintain speed, major handling, engine, throttle, speed control, steering, tracking or balance problems, plus any serious safety conditions or factors which cause excessive rerides or prohibit the driver from doing a satisfactory job.

Other problems should also be noted in comments, but should not be cause for withholding credit. Included in this category are difficulties such as speedometers needing adjustment, minor vibrations, personal dislike of a particular boat design, and problems that develop during the tournament which are not the fault of the promotional boat owner. In cases where credit is questionable, the AWSA Towboat Committee will investigate and make the final determination.

Regional and National Towboat Inspection

All USA-WS approved towboats that qualify for use at a Regional or National Tournament will be inspected prior to the opening events to establish that they are in acceptable condition.

Regional and National Towboat Assignment Draw And Posting

a) Regionals: The assignment of boats to events or groups of events shall be done by random draw. The draw for towboat use shall be done publicly and posted the day before the competition begins.
b) Nationals: The grouping of events for towboat assignment shall be done by USA-WS headquarters and the assignment of groups shall be by random draw. The towboat assignments shall be completed and posted by headquarters by July 1st preceding the respective Nationals. Based on a 3 year cycle, the groupings of events shall remain unchanged and the groupings will be rotated annually through the boats qualified to participate in the Nationals. Every 3 years USA-WS Headquarters will reevaluate the groupings to insure a relatively equal number of pulls for each group, and the groupings will again be assigned by random draw.
c) For AWSA Regional and National Championship Tournaments each qualifying boat manufacturer may provide one "high horsepower jump specific boat". The 35 MPH jump events in those tournaments shall be equally divided among those manufacturers providing a "high horsepower jump specific boat". If no "high horsepower boats" are available the 35 MPH jump events shall be included in the random draw by all the qualifying manufacturers.

Assignments Declined – Regionals/Nationals

A boat manufacturer may decline to pull any division at Regionals or Nationals. Any event declined will be redrawn. Only the manufacturer may initiate such an action.

Interchanging Propulsion Systems

A manufacturer may test different propulsion system combinations (i.e. engines, propellers, and transmissions) in the same hull. A manufacturer may use any of these USA-WS Approved boat model/propulsion system combinations in USA-WS sanctioned tournaments. All of these USA-WS Approved combinations may receive and combine credit toward qualifying the single boat model for participation in the AWSA Regional and National tournaments. If a manufacturer qualifies to participate in the Regionals and Nationals he may bring any combination of USA-WS Approved towboat model/propulsion system combinations provided that the required number of each combination is provided:

a) Regionals
A minimum of 1 of each boat model/propulsion system/speed control brand combination shall be supplied.
b) Nationals
A minimum following number of boats from each manufacturer participating shall be supplied.
2 Lake Site - 3 boats of similar HP

3 Lake Site - 4 boats of similar HP
4 Lake Site - 5 boats of similar HP

In the case of multiple towboat model/propulsion system/speed control combinations being used, a manufacturer shall be required to provide a minimum of 1 of each combination to be used (unless otherwise lowered by the Chief Driver).

c) A manufacturer may not interchange propeller types (i.e. nibral, stainless steel, machined brass) or propeller size / pitch on the same boat provided for use at the Regional and National Tournaments.

Speed Control: Updating hardware and software

A manufacturer can use approved hardware and software from a currently approved model on a prior year approved model with the approval of the Speed Control Committee. The manufacturer shall make such request in writing to the Speed Control Committee.

Speed Control: Use

Speed Control systems should be used in a manner that ensures that all skiers receive a fair and impartial ride. Sufficient throttle shall be applied to ensure that the system is fully engaged and that there is additional "overhead" or throttle available to allow the system to add any additional throttle as needed. The driver shall not in any way limit or block the throttle once the system is engaged.

Enhancing Wakes for the Trick Event Only

A manufacturer may alter his boat to enhance the wake for the trick event. The method of wake enhancement must be verifiable. The committee must approve the boat with the manufacturer's method of wake enhancement before it may be used in USA-WS sanctioned tournaments.

Hydrogate (Nautique)

The Nautique Hydrogate can be set in one of two positions for slalom or tricks/jump (the gate may not be set in between modes).

- Tricks: The default position is the trick mode. The skier has the option of using the slalom mode. It is the skier's responsibility to inform the boat crew when choosing the slalom option. The skier may choose to change the setting between passes.
- Jump: The default position is the jump mode. The skier has the option of using the slalom mode. It is the skier's responsibility to inform the boat crew of slalom option prior to leaving the dock. It will remain in that position for his turn.
- Slalom: The gate will remain in the slalom mode.

RULE 8 - EQUIPMENT

1. Performance Qualifications: Boats must have the performance necessary to obtain and maintain the required boat speeds (see boat speed) while towing a heavy skier under tournament conditions.

2. Overall length shall be approximately 6m. The beam shall not exceed 2.5m.

3. Towing Pylon: Boats shall be equipped with a towing pylon on the centerline of the boat, located between the transom and near amidship, which shall be a minimum of 65 cm. (25 1/2") and a maximum of 1.2m. (47 1/4") above the water when the boat is standing still with no occupants aboard.

   The entire pylon assembly shall be of fail-safe construction, designed to withstand a minimum loading of 600 kg. (1323 lbs.) through an angle of 70 deg. from the stern on both sides.

   The towing pylon shall have an area integrated in its design for attachment of a trick release mechanism. It is recommended that this area be included both above and below the tow rope attachment location and be located as required to ensure clearance of the rope and /or trick release mechanism from the engine housing. This area for attachment of the trick release shall be cylindrical with a diameter of 50.8 mm (2.00 inches) +0.00 mm, -0.25mm (0.010 inches) and with a minimum height of 28mm (1.10 inches). A centering hole with a diameter of 6.00 mm (0.236 inches), +0.35mm (0.014 inches) -0.00mm and a minimum depth of 1.80 mm (0.070 inches) shall be located on the centerline of the attachment area height and be oriented toward the front of the towing pylon. See the diagram in the appendix.

4. Speed Measuring Device
   Speedometer displays shall be positioned for maximum driver visibility. At least one speed indicating display shall be visible to the boat judge.

   a) All USA-WS Approved Tournament Towboats must be equipped with a Speed Control Device (See Rule 8.10). The speed control device shall have at least one display indicating actual boat speed. The device shall also have a connection for a second optional display. In the case of boats using GPS or a paddlewheel for measuring speed, a single GPS or paddlewheel pickup may be used to supply one or more speed indicating displays

   b) For other approved boats, speedometers which rely on pressure pitot type pickups shall be equipped with at least two independent accurate speed measuring devices.

8.02 Boats

A. General: All tournaments, Class ***F*** and higher, are required to use only AWSA-approved tournament towboats. Contact USA Water Ski Headquarters for approval requirements and details as set forth in the AWSA Towboat Manual.

B. Added Weight: It is the duty of the boat judge, in consultation with the driver, to supervise adding a suitable weight in any event to even out boat balance, wakes, spray, or handling. This weight shall not present a hazard to the boat occupants or potential harm to the boat interior.

For tricks, the skier may place a tournament-supplied weight of between 20-50 kg (44-110 pounds) in the boat (either on the floor by the feet of the release operator or behind the engine cover) with side to side positioning as decided by the skier or release operator.

C. Boat Availability: Any boat that is to be used in the tournament shall remain available until the end of the tournament unless released by the Chief Judge. Only designated persons may occupy official towboats during competition.

D. National and Regional Tournaments: The selection of boats and the assignment of boats to specific events in the National and the U.S. Open tournaments shall be made by USA Water Ski Headquarters. National Towboat selection shall occur no later than July 1st. For Regionals, USA Water Ski Headquarters shall make the selection of boats, and the assignment shall be made by the Chief Judge and the Chief Boat Driver. The same boat and driver shall be used by all contestants in each Slalom and Jumping event, except in situation***s*** where time is a factor and similar boats and drivers of similar abilities are available, ***the Chief Judge may decide*** to use two boats and drivers in the same event in an alternating manner. *Alternating manner* shall mean the next available towboat will be used. However, in Jumping and Slalom tie run-offs only one boat and driver shall be used. For the Tricks event, the skier may select a boat from any of the designated towboats.

E. Other Tournaments: At all other tournaments, the selection of towboats shall be established by the Chief Boat Driver with the approval of the Chief Judge from the available towboats. The same

boat and driver shall be used by all contestants in each Slalom and Jumping event, except in cases where similar boats and drivers of similar abilities are available, in which case the Appointed Judges, by majority vote, may elect to use two boats and two drivers in the same event in an alternating manner. However, in Jumping and Slalom tie run-offs, only one boat and driver shall be used.

For Tricks, all types of boats furnished for the tournament will be made available by the tournament committee. Two teams of drivers and boat officials may be assigned to the Tricks event at the option of the Chief Judge.

F. Towboat Breakdown: When a towboat breakdown occurs, the Chief Driver with the concurrence of the Chief Judge may select a similar towboat to complete the event. For the purpose of towboat malfunction, "similar" shall mean an AWSA-approved tournament towboat of the same power and design (i.e., inboard, 351 c.i.). For Regionals, Nationals and Cash Prize tournaments, any substitute towboat shall be of the same model and manufacturer. However, when running dual boats, the event may be continued with one boat, or if substitution is necessary, the two boats continuing the event must be of the same model and manufacturer.

8.10 Speed Control

A. All tournaments Class C and above are required to use speed control.

B. The principal job of the speed control is to provide independence from the manual operator and to give speeds as close as possible to the ideal times.

C. The boat judge and driver shall jointly agree on the setting of the speed control and the allowed adjustments, with the goal of having the device produce ideal times for each pass. If agreement cannot be reached the Chief Judge, or his designee, shall make the decision.

D. A table showing the allowed ranges for all adjustable speed control parameters, and the circumstances under which each of these may be changed, and by whom, is provided in the Appendix.

E. If the speed control unit becomes inoperable and cannot be quickly repaired, and a replacement boat or unit is not available, the tournament shall be continued with manual driving with no other effect.

F. When the speed control cuts out or fails to operate properly or there is otherwise a deviation from normal operation (i.e., a malfunction), the skier is entitled to a reride for failure of tournament-supplied equipment. (See 7.01, 9.10 and 10.10.B.4) (See Rules Interpretations) If the time is out of tolerance due to a malfunction of tournament supplied equipment the skier may accept the highest score with a good time or receive an optional reride with a protected score equal to the highest score with a good time. (See rule 10.10.B.4 and Interpretations)

G. Tournaments are only allowed to use speed control devices tested in conjunction with the towboats approved for use by the Towboat Committee. Approved towboats, including equipment as tested, are listed on the USA WS website under the Towboat section.

H. Software changes are permitted as approved by the Towboat Committee at any time during the season, except that no changes that affect skier pull will be permitted between July 1 and the conclusion of that year's National Tournament.

PARTICIPATION IN REGIONALS, NATIONALS AND U.S. OPEN

Record Capability Approved Boat models which participate in 20% or more of the traditional class C or higher tournament events held during the preceding year in a given Region are invited to pull each of those AWSA Regional Championships where it has qualified. Boat models that participate in all 5 AWSA Regional Championships and receive a positive performance report from four (4) of the five (5) Regions will be approved to pull the National Championships. Boats participating at Regional and National Tournaments must meet these specific requirements:

A. REGIONALS

1. The boat must be a current year or previous year USA-WS Approved model.
2. Manufacturers must provide the appropriate number of boats as determined by USA Water Ski in conjunction with the chief driver for each respective Regional Tournament.
3. For each speed control system provided by the manufacturer at all 5 Regional Tournaments the software and hardware for each brand must be the same and must be the latest version that has been approved by the AWSA Towboat Committee as of July 1 directly preceding the respective Nationals.
4. If the above conditions are not met the chief driver of the Regional Tournament shall inform the Regional EVP and the EVP shall decide if the boats have met the requirements to participate.

B. NATIONALS

1. Boats must be a current year or previous year USA-WS Approved model.
2. USA-WS, in conjunction with the Chief Driver of the National Tournament, shall determine the number of boats required.
3. Speed Control requirements are the same as Regionals.

A boat model that pulls the National Championships will be recognized by USA-WS (and may be promoted by the manufacturer) as a National Tournament Towboat.

A boat manufacturer which has qualified and has pulled two (2) consecutive National Championships will be eligible to be invited by USA-WS to participate in the U.S. Open Water Ski Championships and other major national and international competitions sponsored and organized by USA-WS.

Upon payment of the appropriate sponsorship fees, the manufacturer may promote and market that specific boat model as an Official Towboat of the U.S. Open Water Ski Championships.

A boat model which has qualified to pull the National Championships will be recommended and supported by USA-WS to be invited to pull IWWF Championships.

A minimum of 6 Pan American Region sanctioned tournaments must be pulled to qualify a specific boat model for international approval. The five U.S. Regional Tournaments and the U.S. National Championships are Pan American Region Sanctioned Tournaments.

REGIONAL TOURNAMENT QUANTITATIVE REQUIREMENTS

It is required that each towboat manufacturer pull 20 percent of the events in a particular region to be considered to tow the Regional Championships. A manufacturer can achieve the 20% participation requirement to pull Regional Championships based on all towboat models – not just a single model. Manufacturers will receive towboat credit for use (or available for use) at a tournament – regardless of speed control system installed.

Quantitative Qualification for Regional Participation (i.e., 20% rule) will be based on the total number of AWSA tournament events held during the preceding one-year cycle. The reporting period for unchanged boat models shall be July 1st through June 30th the following year.

Towboats pulling sanctioned intercollegiate tournaments receive credit in the same manner as they do for traditional AWSA tournaments and count towards the required 20 percent qualification to pull AWSA Regionals. Also, boats pulling the Disabled Nationals and/or the Disabled Worlds (if held in the United States) shall be given credit towards the AWSA Regionals for the region in which that disabled tournament is held. Novice/GrassRoots Series tournaments and clinics will not count for credit.

Unchanged Boats - Credit earning period July 1, 2012 through June 30, 2013

Required Events (20%) to Pull the 2013 Regional Championships

	Slalom	Trick	Jump
East	11	5	5
Midwest	22	14	13
South	26	13	12
South Central	13	6	6
West	27	9	8

New or Modified Boats - Credit earning period October 24, 2012 through June 30, 2013
(Credit period begins at the conclusion of the AWSA Towboat Tests through the following June 30)

TOWBOAT & SPEED CONTROL COMMITTEE CONTACTS

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GEORGE LINDY (Co-chairman)

MIKE HAMILTON (South Central)
CHRIS KOSEK (Athlete Rep)
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